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IMMUNITY IN VIRUS INFECTIONS[1]

By THOMAS M. RIVERS, M.D.

HOSPITAL OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

FOR many years it has been recognized that one attack of certain diseases, now classified as virus maladies, induces an enduring immunity. Because of this fact and since many workers believed that viruses are radically different from other types of infectious agents, there arose in some quarters the idea that immunological and serological phenomena in the virus field differ from those in other fields of infection. This was an erroneous idea because the basic principles underlying serological and immunological phenomena in all fields of biology are identical. These principles, however, may evidence themselves in different manners in the various fields, and the techniques of studying the phenomena associated with them in different fields frequently vary because of the nature and mode of action of the infecting agents. It will be impossible to discuss at this time all the different phenomena and peculiarities associated with immunity in the numerous virus diseases. Therefore, a few general remarks will be made, following which immunological and serological phenomena associated with vaccinia will be discussed in detail.

Immunity is resistance to infection or injury and is demonstrable only in a living host. Such resistance

[1] Delivered on September 26, 1941, as part of a symposium on immunity at the Fiftieth Anniversary Celebration of the University of Chicago.

may be natural or acquired. The acquired form may be associated with certain serological phenomena, for example, complement fixation, agglutination, precipitation and neutralization. It must be remembered, however, that these phenomena, while interesting, may not be directly responsible for the immune state of a host.

One of the most striking immunological phenomena in the virus field is the complete and enduring immunity that follows many of the diseases in this category. It is so striking that there was a tendency at one time to make generalizations to the effect that all virus diseases are followed by a lasting immunity. Now we know that this is not true. While smallpox, chicken pox, measles and yellow fever are followed by a protracted immunity, other virus diseases, *e.g.*, influenza and common colds, produce protection of short duration. An awareness of the difference in the duration of immunity following different virus diseases immediately raises the question as to why some of them induce a lasting immunity and others do not. Many workers in this field believe that a life-long immunity to a second attack of a virus disease is due to a persistence of the virus in the recovered host. Inasmuch as circulating antibodies against yellow fever virus have been found in a recovered host for as long as fifty years after an attack of the disease during which time no further contact with the active agent has occurred, the statement just made about persistence of virus is particularly applicable to yellow fever. Such a persistence does not mean that an immune individual is capable of spreading disease, because it is most likely that the virus is stored in some remote part of the body within living cells where it can not come in contact with circulating antibodies and from which point it can not, for one reason or another, reach the outside world.

A statement to the effect that an infectious agent can persist for so long a time in a host in the presence of neutralizing antibodies seems to shock some workers. There is nothing strange about the situation if one realizes that viruses multiply and carry on all their activities within living cells. Furthermore, while situated intracellularly the active agents can not be attacked by antibodies. Consequently, if a virus and its host cells multiply at approximately the same rate and if the host cells are not destroyed by the virus, the two can live together happily year after year without the infecting agent ever being subjected to the action of humoral antibodies. There is ample experimental evidence to show that such a state of affairs can and does exist under certain conditions.

Thus, following certain virus diseases the prolonged or enduring immunity is probably due to a long-term sojourn of the virus in the host or its persistence throughout the host's life. From such a statement one might infer that the reason for the absence of an enduring immunity following attacks of certain virus diseases is due to the fact that the inciting agents of these maladies are not capable of permanently establishing themselves in an infected host or that they do not persist long enough in a host to bring about a profound immunity. Why the virus can not permanently establish itself in some diseases is not known. Perhaps the type of tissues involved is responsible. For example, it is possible that in the case of the common cold and influenza the viruses attack superficial tissues, establish themselves in such tissues and would lead to an enduring immunity if these tissues were not themselves temporary. In other words, the superficial cells lining the respiratory tract are being thrown off at regular intervals to be replaced by new cells from deeper layers and do not provide a permanent abode for viruses.

This explanation for the persistence and lack of persistence of immunity to certain virus diseases may not cover the field completely, and doubtless some workers will object to it. On the other hand, there are good reasons for believing that the conditions described play a part in the picture. In any event, it is well known that a plant once infected with a virus, although it may later assume a fairly normal appearance, still carries the virus and is refractory to reinfection. Moreover, Kunkel has shown that one virus disease of plants can be cured by treatment at a temperature which inactivates the virus without injury to the plants and that the cured plants return to a state of susceptibility to infection.

What has been said about the persistence of immunity following attacks of virus diseases has a bearing on the production of immunity by means of vaccines. At the beginning of the virus era it was not unusual to hear that a protection could not be induced except by the use of vaccines containing active viruses. While it is true that immunity against many virus diseases has not been induced except by the use of active agents, it has been possible in the case of others, *e.g.*, equine encephalomyelitis, rabies and influenza, to produce an appreciable amount of protection by means of inactive agents, provided sufficient quantities of them are used. If enduring immunity is due to persistence of virus in a host, then one would not expect inactive viruses to produce a prolonged immunity because of their inability to establish themselves and continue to multiply. This appears to be the case, because whenever inactive viruses are used it is recommended that vaccinations be repeated at stated intervals.

The fact that viruses multiply within living susceptible cells and can not be attacked by antibodies while

within such cells has a bearing on serotherapy of virus diseases. It is generally believed that once a virus has invaded a host and has manifested itself by signs and symptoms of illness, it is too late to modify materially the course of the disease by the therapeutic administration of immune serum. This belief has arisen as the result of many negative reports regarding the value of immune serum in the treatment of virus maladies. If the belief is justified, and it undoubtedly is in the case of many virus diseases, one has to seek for an adequate explanation of such findings further than the fact that viruses multiply in cells and can not be attacked by antibodies while so situated. In order to account completely for the negative findings regarding serum therapy, it is necessary to assume that all the cells that are going to be infected in a particular host by a virus have been infected by the time signs and symptoms of illness become evident. This assumption is substantiated by a considerable amount of experimental work. Fite and Webster have shown that after instillation of louping ill virus in the noses of mice the active agent is present in the brain four days before the animals evidence signs and symptoms of illness. Galloway and Perdrau found that after instillation of louping ill virus in the noses of monkeys the active agent was well distributed throughout the central nervous system several days before the animals showed signs of sickness. Hurst instilled equine encephalomyelitis virus into the noses of monkeys, sacrificed them at different times after inoculation, tested various parts of their central nervous systems for the presence of virus, and correlated his findings with clinical observations made on the monkeys before they were killed. According to him, all parts of the central nervous system except the cord contained virus within thirty hours after onset of fever, and several hours later, at the time of onset of nervous symptoms, even the lumbar cord was infectious. Webster and Clow dropped the virus of the St. Louis type of encephalitis into the noses of mice, sacrificed some at different times in order to test for the presence of virus in various parts of the brain and cord, killed others to determine the time of appearance and progression of lesions, and allowed others to sicken and die in order to determine the time of onset of clinical signs and symptoms. The data obtained in this manner clearly showed that virus was present in tissues twenty-four to forty-eight hours before the appearance of lesions detectable by means of the microscope and that all parts of the brain and cord contained large amounts of virus before the animals became ill. Faber and Gebhardt conducted similar experiments with monkeys that had been infected by means of intranasal instillation of poliomyelitis virus. Their findings indicated that by the fifth, sixth or seventh day after inoculation, at which time only an occasional rise of temperature or tremor and hyperesthesia were present, and before paralysis had occurred, virus was distributed throughout the central nervous system.

Following the general remarks about immunity in virus diseases, it seems advisable to discuss in detail certain immunological and serological phenomena associated with vaccinia. It is generally accepted that a successful vaccination against smallpox in which active vaccine virus is used results in a satisfactory immunity which endures for a varying period of time, *i.e.*, from several years to a lifetime. Many attempts have been made to obtain satisfactory immunity both in lower animals and in human beings by means of inactive vaccine virus. While a low-grade protection can be obtained in this manner in lower animals, provided large amounts of inactivated vaccine virus are used, no definite evidence as yet has been brought to indicate that any of the inactivated vaccines employed are of real value in the protection of human beings against smallpox.

In some virus diseases, the only humoral antibody that has been demonstrated is one which neutralizes the inciting agents, as is the case in poliomyelitis. In other virus diseases, for example, in Shope's papilloma of rabbits, complement-fixing and neutralizing antibodies have been demonstrated, and apparently they are identical, reacting to a single antigen, the virus, in different ways under different conditions. In still other virus diseases, for example, in infectious myxomatosis of rabbits and vaccinia, there appears to be a multiplicity of antigens and antibodies. In fact, the serological studies of vaccinia and infectious myxomatosis of rabbits have gradually made it obvious that many of the phenomena observed in other types of infectious diseases are also observed in the virus field. Moreover, methods used for investigating these phenomena in the virus field are in many instances identical with or similar to those employed in other biological fields.

Sternberg in 1892 demonstrated that the serum of an animal recovered from vaccinia possesses the property of neutralizing the activity of the virus. In 1899 Béclère, Chambon and Ménard confirmed and extended Sternberg's observations. In addition to this, they showed that sera of human beings and monkeys convalescent from variola possess neutralizing antibodies for vaccine virus. The first definite demonstration that flocculation occurs in a mixture of vaccinia-immune serum and vaccine virus was made in 1904 by Freyer. In 1906 Jobling demonstrated that complement is fixed in the presence of a mixture of vaccine virus and serum from calves convalescent from vac-

cinia. Paschen reported in 1913 that elementary bodies of vaccinia are specifically agglutinated by vaccinia-immune serum.

In 1925 Gordon in a Medical Research Council Report presented the results of his extensive study of the antibodies found in vaccinia- and variola-immune sera. He again took up the question of complement fixation and definitely showed that the viruses of vaccinia and variola specifically fix complement in the presence of homologous antisera. He also showed that vaccine virus fixes complement in the presence of variola-immune serum and *vice versa*—phenomena indicating the antigenic similarity or identity of the viruses. This work has been fully confirmed by Parker and Muckenfuss and by Craigie and Wishart. Furthermore, Gordon found that a flocculation occurs in mixtures of vaccinia-immune serum and vaccine virus, and showed that the reaction is specific in that vaccinia-immune serum flocculates only in the presence of vaccine virus or smallpox virus. He spoke of the reaction as an agglutination; but as will be pointed out presently this was a mistake, because the flocculation was undoubtedly due to two phenomena, *viz.*, a precipitation of soluble substances and an agglutination of elementary bodies. Indeed, some of the tabulated results of his experiments should have indicated to him that a soluble substance separable from the virus was playing a part in the complement-fixation reactions as well as in the flocculation tests.

In 1929 Burgess, Craigie and Tulloch described in a Medical Research Council Report the results of their work on the vaccinia-variola flocculation test in which they were able to confirm most of Gordon's observations. In 1931 another report by Craigie and Tulloch on the same matter extended their previous observations. Ledingham, in 1932, using specially prepared elementary bodies of vaccinia, showed by means of the hanging drop method a specific agglutination of the bodies in the presence of vaccinia-immune serum. In 1932 Tulloch reported that in ordinary preparations of vaccine virus there is present a soluble fraction, separable from the virus itself, which gives a precipitin reaction when mixed with immune serum. Shortly after this report, Craigie confirmed Tulloch's observation and stated that the flocculation test described by Gordon with crude virus suspensions involved both a precipitin and an agglutination reaction, the precipitin reaction being caused by a soluble substance separable from the virus, while the agglutination reaction represented an aggregation of elementary bodies. In 1934 Craigie and Wishart reported that the soluble fraction is made up of two components; one, designated as L, is labile and no longer active after being heated at 56° C; the other, called S, is stable at 95° C. Craigie and Wishart later stated that L and S are probably not separate entities but form an LS complex. Inasmuch as the stable substance gives a Molisch reaction, Craigie, Smith and Ch'en at one time believed it to be a polysaccharide derived from the virus. Parker and I have confirmed most of Craigie's observations, but do not agree with him that the stable substance (S) is a polysaccharide; it is a protein with particular properties. Moreover, Parker later showed that under certain conditions L and S are separable and are not always united in an LS complex. Recently, in 1938, Craigie and Wishart stated that they now believe the LS complex to be capable upon storage of breaking up into its separate components L and S.

At this stage of our knowledge there appeared to be in vaccinia-immune serum antibodies capable of doing the following things: neutralize virus; agglutinate elementary bodies; fix complement; and precipitate specific substances which had been separated from the virus. The agglutination of elementary bodies may take place because of the reaction between the soluble substances, L and S, adsorbed on their surfaces, and the L and S antibodies. On the other hand, Craigie believes that there is in addition to the L and S substances adsorbed on elementary bodies, another agglutinogen, X, which gives rise to X agglutinins. The antibodies that fix complement and produce the precipitin and agglutination reactions are likely to be the same, merely exhibiting their activity in different ways when they cause agglutination, complement fixation and precipitation. There is reason to believe that neutralizing antibodies are different from the others, because, as Parker has shown, an animal immunized with purified S is not immune to vaccine virus nor does its serum neutralize more than a minimal amount of virus in spite of the fact that it causes the other reactions that S antibodies should. Moreover, it is easy by adsorption to remove from vaccinia-immune serum L and S antibodies and with some difficulty the agglutinins also without diminishing the neutralizing titer of the serum.

Several years ago Dr. Smadel and I undertook further investigations of the LS complex spoken of by Craigie. In addition to this, we also endeavored to obtain more information regarding the existence of unrecognized antigens in vaccine virus. The first thing we did was to extract washed elementary bodies of vaccinia with N/20 NaOH at 56° C. for a short time and then quickly neutralize the material. This extraction yielded a nucleoprotein which gave a precipitin reaction with unadsorbed vaccinia-immune serum. Such a serum from which all the L and S antibodies had been removed by adsorption still possessed its full ability to precipitate in the presence of the nucleoprotein antigen extracted from the ele-

mentary bodies. Inasmuch as Smadel, Dubos and Lavin have shown that S is not a nucleoprotein and in view of the results of adsorption just described, it is obvious that S and the nucleoprotein extracted from elementary bodies are distinct antigenic entities.

We next investigated the relation of the nucleoprotein antigen to Craigie's X agglutinogen and an antigen which produces neutralizing antibodies. According to Craigie, the X agglutinins are the antibodies left in a vaccinia-immune serum following adsorption with L and S. Such a serum adsorbed with the nucleoprotein antigen removed some of Craigie's X agglutinins but not all of them. Consequently, we believe that Craigie's X agglutinins are produced as a reaction in part to the nucleoprotein extractable from elementary bodies and in part to some other antigen or antigens of the virus. In other words, Craigie's X agglutinogen is not a single substance. Serum adsorbed to remove all L and S and all nucleoprotein antibodies still possesses full neutralizing value. Thus, it is obvious that the extractable nucleoprotein antigen is not responsible for the production of neutralizing antibodies.

By the proper means L or S antiserum can be obtained. When either of these sera is mixed with a fresh filtrate from the skin of a rabbit infected with vaccine virus, both L and S are removed. Because of this fact Craigie stated that the two substances L and S probably do not occur separately but as an LS complex. On one occasion, however, Parker obtained a dermal filtrate in which he thought that L and S occurred separately in that one could be removed completely without the entire removal of the other component. Craigie also was able on one occasion to confirm this finding of Parker. Nevertheless, the original findings of Craigie are the ones usually encountered. Inasmuch as questions about the identity of L and S were still open, Dr. Smadel and I for several years have been pursuing the matter.

Fresh virus-free filtrate from vaccinia-infected skin of rabbits contains both L and S. When heated at 56° C., L no longer is precipitated in the presence of its antiserum; however, it inhibits L antibodies so that when unheated L is added to the mixture no precipitate occurs. When heated dermal filtrate is treated with dilute alkali and heat for a short time and then neutralized, it neither inhibits L antibodies nor does it precipitate in the presence of S antibodies; but a filtrate treated in such a manner inhibits S antibodies. If the filtrate is degraded further, it no longer inhibits S antibodies. Moreover, purified S, obtained according to the method of Parker and Rivers, was found to inhibit L antibodies while still capable of precipitating with S antibodies. After the purified S was treated with dilute alkali and heat and then neutralized, it no longer inhibited L antibodies, did not precipitate in the presence of S antibodies, but did inhibit S antibodies. From these findings it was concluded that LS is probably a single substance with two reactive components, L and S, which are degraded with different degrees of ease. At that time we were aware of the fact that definite proof of this idea of the nature of L and S was lacking and that such a conception was directly opposed to the occasional findings of Parker and Craigie in which L and S apparently were separated from each other by means of adsorption.

Believing that some of the newer techniques might be of assistance in purifying the LS complex and acquiring further information regarding its nature, Shedlovsky and Smadel attempted by means of the Tiselius apparatus to obtain LS in pure form from a filtrate of dermal pulp. They soon found that it would not be possible to obtain pure LS by this means alone. Then they used a combination of methods, fractionation by means of precipitation and by electrophoresis. When the dermal filtrate was brought to a pH of 4.5, a precipitate formed which was partially soluble at pH 6.5. If this procedure was carried out properly, it was found that the material which went back in solution at pH 6.5 possessed the nature of a globulin and gave evidence of being a single substance both in the ultracentrifuge and in the Tiselius apparatus. Moreover, this substance reacted equally well with L and S antibodies. When heated at 56° C. it inhibited L antibodies but still precipitated with S antibodies. When treated with dilute alkali and heat and then neutralized, it did not inhibit L antibodies, did not precipitate with S antibodies, but did inhibit S antibodies. As a result of this work it seems obvious that L and S are components of a single substance.

The data just presented regarding L and S are believed to be correct and their meaning is obvious, but they do not contain an explanation of the occasional findings of Parker and Craigie in which L and S were apparently different substances. These men are excellent investigators and it is not reasonable to believe that their observations were false. Therefore, some explanation for their occasional findings was sought. A hypothesis was formed to the effect that L and S is one substance with two serologically reactive components and that under usual conditions the activity of L is more easily suppressed than that of S. On the other hand, it was believed that it might be possible for events to occur the other way around under exceptional conditions, as for instance in the presence of special enzymes. Consequently, Smadel and Hoagland tested the effect of certain crystalline enzymes on the activity of purified LS. Very quickly it was shown that crystalline chymotrypsin acting on pure LS destroys the activity of S, leaving that of L

unimpaired. With these findings all the parts of the puzzle, L and S of vaccinia, seemed to fall in place, and now more than ever it seems reasonable to conclude that they are nothing more than different components of a single protein molecule.

Little or nothing is known about the antigen that gives rise to antibodies that neutralize the virus of vaccinia. Indeed, most workers have been unable to remove these antibodies from immune serum by means of adsorption with purified elementary bodies. On the other hand, Salaman believes that there is a union between elementary bodies of vaccinia and neutralizing antibodies and that if sufficient amounts of elementary bodies are used the neutralizing substances can be adsorbed from immune serum. An assessment of information regarding the antigen that incites the production of neutralizing antibodies and the manner in which such antibodies act reveals that much remains to be learned concerning this the most important of all subjects connected with immunity to vaccinia.

From my remarks regarding viruses in general and vaccine virus in particular, it should be evident that there is nothing peculiar about immunity in virus diseases. Principles that hold in other fields operate also in the virus domain. Furthermore, it should be obvious that generalizations about immunity in virus maladies can be made with no more assurance than about resistance to other types of infection. Immunological and serological phenomena in each virus disease present special problems that have to be met not through generalizations but by specific experiments.

NORMS OF GROWTH

By Professor EDWIN B. WILSON

DEPARTMENT OF VITAL STATISTICS, HARVARD SCHOOL OF PUBLIC HEALTH

IN the *Proceedings* of the National Academy of Sciences (Vol. 21, pp. 633–4, 1935) I gave average heights and weights of 275 school girls for consecutive ages 7 to 16 years inclusive with the correlations of the heights and of the weights in the different years based on the measurements obtained in Dr. W. F. Dearborn's growth study. As many persons knew that the study involved many more than 275 girls, some have wondered why I took only the 275 for whom records were available for each and every one of the ten years from 7 to 16.

The answer, unless I am mistaken, is to be had by considering the aims of a growth study. If we desire to establish stable norms of height and weight or of other measurements at different ages we should take, of course, large samples because the standard error σ of an average is that of the distribution divided by the square root of the number n in the sample. Thus at 13 the average height was 153.40 cm with a standard deviation of 7.42, which means $153.40 \pm .45$ for the average if based on only 275 girls, whereas if we had measurements of four times as many the standard deviation of the mean would be only .22. However, for such norms one need not trouble with the continuity involved in growth studies; one could make a cross-sectional survey involving a large number of persons at each of the different ages.

Growth, however, is a continuous process and the amount of growth between two given ages is measured by a difference or increment in the measures. If we have l girls of one age and m different girls of another age as in cross-sectional studies with means Z and W, respectively, for some measurement and with standard deviations σ_z and σ_w, the sampling error of the difference $W - Z$ would be

$$\sigma^2_{W-Z} = \frac{\sigma^2_w}{m} + \frac{\sigma^2_z}{l};$$

but if we had n girls of both ages, as in growth studies, and the averages were X and Y, the sampling error of the difference could be obtained directly from the differences $y - x$ or indirectly from the correlation coefficient r between corresponding values of x and y as

$$\sigma^2_{Y-X} = \frac{\sigma^2_x + \sigma^2_y - 2r\sigma_x\sigma_y}{n}.$$

In cases in which r is high this value may be much smaller than the former when the number of persons involved is about the same, or, to put it differently, the second value may be statistically as good from a relatively small number of individuals, as the first is from a much larger number.

For example, the lowest correlation of the heights in successive years was found to be $r = .96$. If we assume σ_x and σ_y nearly enough equal so that they may be put equal, and equal to σ_z, σ_w for corresponding ages, without serious error, and if we take $l = m = n$ the first formula gives $2\sigma^2_x/n$ and the second gives $2\sigma^2_x(1-r)/n$ or only .04 as much; to put it inversely, we should have to have $l = m = 25n$ to obtain from the first formula a sampling error as small as that obtainable from the second, or we should need nearly 6,400 girls taken at each of the years to give as good an estimate of average growth as we got from 275 taken at both years—provided we trust our statistical formula.[1]

[1] This proviso may seem odd. We have, however, to remember that statistical formulas are mathematical theorems proved on certain assumptions which may not hold

This raises the further question of how to combine the data in case there are, as there needs must be, irregular omissions in the data. It is a general rule of statistics that if we have two independent and consistent[2] estimates Q_1 and Q_2 of a quantity with two standard deviations σ_1 and σ_2, the weighted mean $Q = pQ_1 + (1-p)Q_2$ will have the smallest value of σ_Q when $p = \sigma_2^2/(\sigma_1^2 + \sigma_2^2)$ and $\sigma_Q^{-2} = \sigma_1^{-2} + \sigma_2^{-2}$. Hence, applied to the estimates of amount of growth $Y - X$ and $W - Z$, the best estimate would have the sampling error

$$G = \frac{\sigma^2_{W\text{-}Z}(Y-X) + \sigma^2_{Y\text{-}X}(W-Z)}{\sigma^2_{W\text{-}Z} + \sigma^2_{Y\text{-}X}}.$$

$$\frac{1}{\sigma_G^2} = \frac{n}{\sigma_x^2 + \sigma_y^2 - 2r\sigma_x\sigma_y} + \frac{lm}{l\sigma_w^2 + m\sigma_z^2}$$

If we use for illustration the assumption $\sigma_x = \sigma_y = \sigma_w = \sigma_z$, $l = m = tn$,

$$\sigma_G^2 = \frac{2\sigma_x^2(1-r)}{n} \cdot \frac{1}{1 + (1-r)t},$$

and it is clear that if r is large so that $1 - r$ is small, t must be considerable before an appreciable reduction is made in σ_G.

It is well known in statistics that the sampling error of a quantity involves the method of estimating the quantity. Thus if a universe is symmetrical, its center may be estimated from a sample drawn from the universe by the mean of the sample or by its median or by its mode or by the mean of the least and of the greatest element in the sample, but the standard deviations of the four estimates will be different. So in the above problem if we should undertake to form from X and Z at the earlier age and from Y and W at the later age the overall age means

$$\frac{nX + lZ}{n + l} \text{ and } \frac{nY + mW}{n + m}$$

and their difference

$$G = \frac{nY}{n+m} - \frac{nX}{n+l} + \frac{mW}{n+m} - \frac{lZ}{n+l}$$

we could get σ_G^2 as

$$\sigma_G^2 = \frac{n\sigma_y^2}{(n+m)^2} + \frac{n\sigma_x^2}{(n+l)^2} - \frac{2nr\sigma_x\sigma_y}{(n+m)(n+l)} + \frac{l\sigma_z^2}{(n+l)^2} + \frac{m\sigma_w^2}{(n+m)^2},$$

but this would be a bad way to estimate G if r were large and l and m were not large compared with n. Indeed, if we take the simple illustrative case as before, $\sigma_x = \sigma_y = \sigma_z = \sigma_w$, $l = m = tn$ we have

$$\sigma_G^2 = \frac{2\sigma_x^2(1-r)}{n(1+t)^2}\left[1 + \frac{t}{1-r}\right]$$

This is greater than if we had omitted altogether the extra observations which were not common to both years unless $t \geqq (2r-1)/(1-r)$. If $r = .96$ we should have 23 times as many non-common as common observations before we should be as well off using general means to estimate growth.

This discussion will show, it is hoped, how important it is when establishing norms for increments of growth (*i.e.*, of *growth*) to maintain throughout the study a discipline on the part of the students and of the studied which will bring about the maximum continuity of the record.

for the observations to which the formulas are applied. Thus if the theoretical sampling error of some quantity Q for samples of n items be σ, and if we take a considerable number of samples of n items we may find that the standard deviation of the values of Q observed in the different samples is considerably more than the theoretical value σ. If we evaluate the amount of growth by subtracting averages taken for two groups at each of two ages and also evaluate it by averaging the amount of growth between those ages for a single group measured at both ages, doing this a considerable number of times for different single groups on the one hand and for different pairs of groups on the other, we may well find that the variations observed are not those given by theory and further that they are not in the same ratio as that given by theory. It often takes extended experience to correct for such differences between theory and observation, but in the absence of such experience we have to make our estimates according to the theory.

[2] The qualification that the estimates have to be consistent is usually omitted. There are cases to be found in the literature where inconsistent estimates have been combined by the rules which I believe to be appropriate only for consistent estimates. Thus W. S. Eichelberger and Arthur Newton, "The Orbit of Neptune's Satellite and the Pole of Neptune's Equator," Astronomical Papers of the American Ephemeris, Vol. 9, Pt. 3, 1926, pp. 275–337, discuss on p. 329 the value of the reciprocal of the mass of Neptune, finding from reduction of the visual observations $19176 + 25$ and from reduction of the photographic observations 19655 ± 36. The difference is 479, which is many times as much as would be consistent with the indicated errors, yet they obtain 19331 ± 21 by combining the observations as if they were consistent, even reducing the estimated error of the combination in accordance with the rule. With the high standard in the reduction of observations set for the American Ephemeris and Nautical Almanac by Simon Newcomb over many years, I have to be somewhat hesitant in suggesting the above criticism, yet I must say that I have never seen any theory of least squares which seems to me to validate the process by which the final result 19331 ± 21 is obtained from its immediate antecedents.

OBITUARY

WILLIAM REES BREBNER ROBERTSON
1881–1941

W. R. B. ROBERTSON was born on May 31, 1881, and spent his early life on a farm at Manchester, Kansas. He died in Iowa City on March 15, 1941. He was one of C. E. McClung's eager students of cytology in the University of Kansas (A.B., 1906; A.M., 1907). He also studied with E. L. Mark, 1909–1912, in Harvard (Ph.D., 1915). He then spent the rest of his

life in the University of Kansas, the University of Missouri, the Kansas Agricultural Experiment Station and the University of Iowa. He was a life member of the Kansas Academy of Science; fellow of the American Society of Zoologists; member of the American Society of Naturalists, the Genetics Society, Medical Association, Poultry Society, Eugenics Research Association, Phi Beta Kappa, Sigma Xi and others.

Robertson's early papers, 1915–17, dealt with chromosomal inequalities, deficiencies, shapes and homologies in relation to synapsis, taxonomy and genetics in seven species of the subfamily Tetriginae, as well as in a few species of the larger grasshoppers. During the period of 1920–27, he derived a valuable set of data, including many skins and feather samples, from the extensive breeding of turkeys to which he devoted himself with meticulous care and great zeal. He never published on the turkey data but left them in such form that they will be available, it is believed, for forthcoming contributions of importance to the understanding of inheritance in these birds.

In 1927, Robertson came to the Department of Zoology of the Kansas State College as guest collaborator. He remained for three years, devoting himself exclusively to the cytogenetics of *Paratettix texanus* Hancock and *Apotettix eurycephalus* Hancock. He published five papers in 1930 and 1931 covering the work of this period. These researches dealt with the chromosomal relations in partheno-produced (I think that he introduced this useful word) pigmy locusts, including goncmeric grouping, synapsis-like tendencies, types of parthenogenesis, hybrid vigor, split chromosomes, the origin of the rarely partheno-produced males and other cytogenetic features of partheno-production. Subsequent joint papers (1933, 1941) have reported on inheritance in *Corthippus longicornis* and his accurate concatenation of cytology with the gross genetics of x-ray induced aberrancies in *A. eurycephalus,* including an autosome-sex chromosome translocation.

Robertson was extremely sensitive by nature and, like most people of similar dispositions, he commonly misconstrued the intentions and actions of his family, friends and colleagues to a greater degree, perhaps, than he was himself misunderstood and ill-judged. Nevertheless, he was a staunch and loyal friend and beneficently devoted to the welfare and progress of his students, the work of several of whom he directed to doctorate theses. As a scientist he was extraordinarily painstaking, exacting and demanding of high standards in his own and students' researches. Consequently, he proceeded slowly and, when measured beside stream-lined researches, perhaps awkwardly, and thus in at least a few instances he was subjected to the facile and inconsiderate opprobrium of dilatoriness. Due to his peculiarly sensitive nature he was unable to meet such imputations with that saving complex of disdain, aplomb and sense of humor so essential to the peace of mind and welfare of the creative and critically experimental scientist such as he was. But let it be recorded to the enduring excellence of Robertson's scientific character that, although staggered by the forces of financial, spiritual and professional embarrassment, he never relented nor deviated from the high and exacting standards which he had irrevocably set for himself in the days of his apprenticeship with McClung and Mark. It was during one of the most distressing periods for him that the research which will perhaps eventually be considered of considerable significance was accomplished.

In 1930, Robertson went to the University of Iowa. There, with the sagacious, understanding and genial MacEwen, Bodine, Ingram, other staff members and graduate students as colleagues, his long perturbed, thwarted and lonesome spirit was restored to a degree of composure and hope such as he had scarcely experienced since those early days of happy participation in the beginnings of cytogenetics on Mt. Oread. These remaining eleven years of his life were happily devoted to teaching, graduate students, various researches, including further cytogenetics of x-rayed pigmy locusts and some larger grasshoppers. He also gave attention to human heredity and contributed a chapter dealing with the biological background of the family to Jung's "Modern Marriage."

ROBERT K. NABOURS

DEATHS AND MEMORIALS

PROFESSOR WILMER E. DAVIS, professor of plant physiology at the Kansas State College of Agriculture and Applied Science, died on January 17 at the age of seventy-five years.

DR. CHARLES DAVISON, professor emeritus of surgery at the University of Illinois College of Medicine, died on January 19 at the age of eighty-four years.

DR. HARRY CAPPS, assistant professor of psychology, Louisiana State University, soon to have been inducted into the Army, died by suicide on January 17. He was thirty-three years old.

DURING the recent celebration of the fiftieth anniversary of the founding of the School of Mines of the University of Minnesota, the Board of Regents honored its founder and first dean, the late William Remsen Appleby, by naming the School of Mines building "Appleby Hall." A plaque, unveiled at a ceremony in his honor on January 13, will be placed

in the building. Dean Appleby served the School of Mines from its foundation in 1892 until his retirement in 1935. He died on April 8, 1941.

A FELLOWSHIP honoring Walter Lindsay Niles, dean of Cornell University Medical College and attending physician at the New York Hospital, who died on December 22, has been announced by the two institutions. An endowment fund of $100,000, of which more than a fourth has been pledged in advance, is being raised by friends and colleagues of Dr. Niles to provide annual awards to outstanding young men entering the medical profession. The committee directing the effort includes: Dr. Bruce P. Webster, *chairman,* Mrs. Roger W. Straus, Walter C. Teagle, Neal Dow Becker, William H. Jackson, president of the Society of the New York Hospital; Dr. Edmund E. Day, president of Cornell University, and Dr. Malcolm Goodridge, president of the New York Academy of Medicine.

THE three-hundredth anniversary of the death of Galileo Galilei, on January 8, 1642, will be celebrated at the New York Academy of Medicine by placing on exhibit a collection of works and illustrations bearing on his life and accomplishments. The exhibit will be placed on view in connection with the delivery of the ninety-second Anniversary Discourse of the New York Academy of Medicine. Dr. A. A. Brill will deliver the address on "The Freudian Epoch." Both the exhibit and the meeting are open to the public.

SCIENTIFIC EVENTS

THE FOURTH EXPEDITION TO GUATEMALA OF FIELD MUSEUM

WITH plans for completing comprehensive botanical researches, and the collecting of plants representing the varied flora of Guatemala, the fourth botanical expedition to that country for Field Museum of Natural History sailed from New Orleans on December 3. Dr. Julian A. Steyermark, assistant curator of the herbarium, is in charge of the expedition. He is accompanied by Albert Vatter, of Glenview, Ill., a specialist in wild flower photography.

The three previous expeditions to Guatemala, one conducted by Dr. Steyermark, and the others by Paul C. Standley, curator of the herbarium, resulted in collections of many thousands of plants, and further thousands are expected from the present undertaking. This expedition will conclude the preparations for publication of a flora of Guatemala upon which Messrs. Standley and Steyermark have been engaged since 1938.

Dr. Steyermark and his assistant will remain in Guatemala for about ten months. The time will be devoted chiefly to the exploration of those areas which were not investigated by the previous expeditions, as well as to areas whose wealth of vegetation demands greater attention than has been possible to accord it hitherto. Guatemala, despite its small size, has an extensive and varied flora due to the extreme diversity of terrain it offers for plant environments, ranging from plains to high mountains, and from desert to tropical rain forests.

The most difficult task Dr. Steyermark faces is the collecting of plants during the rainy season from areas which at that time reach their maximum of floral development. This is a condition much to be desired from the standpoint of botanical study, but is hard on the explorer since the rainy season in Guatemala means the kind of constant heavy downpours which make life extremely uncomfortable for those who have to expose themselves to the weather.

GRANTS OF THE NATIONAL TUBERCULOSIS ASSOCIATION

THE Committee on Medical Research has recommended to the National Tuberculosis Association that during 1942–43 grants be awarded for:

Chemical Investigations of the Tubercle Bacillus, by R. J. Anderson, Sterling Chemistry Laboratory, Yale University.

Enzymes as Factors in Resistance to Tuberculosis, by M. C. Winternitz and Bruno Gerstl, Laboratory of Pathology, Yale University School of Medicine, and by H. W. Olson, Wilson Teachers College, District of Columbia.

Serum Studies using Tiselius Electrophoresis Apparatus, by Florence B. Seibert, Henry Phipps Institute, University of Pennsylvania.

Research in Roentgenological Technique, by Charles Weyl and S. Reid Warren, Jr., Moore School of Electrical Engineering, University of Pennsylvania.

Variations in Virulence by the Omental Spread Method, by C. E. Woodruff, Wm. H. Maybury Sanatorium, Northville, Mich.

Relation between Diabetes and Tuberculosis, by M. M. Steinbach, Columbia University.

Decision on grants for clinical studies in Boston and New York was deferred pending an investigation by a special subcommittee into the best method of coordinating these independent projects with studies being considered by the American Trudeau Society. Grants considered at this time are not effective before July 1, 1942.

The members of the Committee on Medical Research are: Dr. Wm. Charles White, *chairman,* Dr. Charles

J. Hatfield, Dr. Kendall Emerson, Dr. J. Burns Amberson, Jr., Dr. Ezra Bridge, Dr. Charles A. Doan, Dr. Leroy U. Gardner, Dr. Esmond R. Long, Dr. Karl F. Meyer, Dr. Florence R. Sabin and Dr. David T. Smith.

THE NATIONAL FOUNDATION FOR INFANTILE PARALYSIS

THE third annual report of Basil O'Connor, president of the National Foundation for Infantile Paralysis, has appeared. It covers the period from October 1, 1940, to September 30, 1941. During the year the foundation received a cash income of $1,036,480. Seventy-two grants and appropriations were made, amounting to $805,562. These grants were awarded for Virus Research, for Nutritional Research, for After-Effects Research, for Education and for Epidemiology—Epidemics. They include:

The University of Wisconsin, $62,500, to study the metabolism of monkeys as a part of the study of the influence of nutrition on susceptibility to poliomyelitis.

University of Michigan School of Public Health, $40,000, to continue to give aid for the express purpose of creating facilities to train virologists and to study virus diseases, with particular emphasis on poliomyelitis.

University of California, the George Williams Hooper Foundation, $15,000, to continue and extend studies in the epidemiology of poliomyelitis in the eleven Western states with special reference to human equine encephalomyelitis, St. Louis encephalitis and other types of encephalitis. $6,300, to conduct epidemiological studies; to study animals, birds, insects and humans for the presence of evidence of infection with viruses of St. Louis encephalitis, Western equine encephalomyelitis and poliomyelitis.

Harvard Medical School and Surgical Research Laboratory, Boston City Hospital, $3,000, to study the gastrointestinal tract as the portal of entry of virus in experimental poliomyelitis. $17,315, for the purchase of supplies for laboratory research studies.

Yale University School of Medicine, $13,000, to continue the study of the distribution of the virus of poliomyelitis in human beings and in nature, during epidemics and inter-epidemic periods.

The University of Southern California School of Medicine, $10,000, to continue laboratory studies of comparison of strains of poliomyelitis virus recovered in Los Angeles. $5,000, to conduct studies on isolation of poliomyelitis virus from asymptomatic non-contacts.

The Johns Hopkins University School of Hygiene and Public Health, $9,300, to conduct an epidemiological study of poliomyelitis by determining the disposition of poliomyelitis virus neutralizing antibodies among residents of an urban community.

University of Toronto, Connaught Laboratories, $8,800, to continue an attempt to develop more effective methods of recovery of poliomyelitis virus.

The Children's Hospital Research Foundation, Cincinnati, Ohio, $11,300, to continue to study the nature of human poliomyelitis, with particular reference to distribution of the virus in different levels of the alimentary tract; to study the distribution of poliomyelitis virus in cynomolgus monkeys succumbing to infection by the oral route; to conduct a search for poliomyelitis virus in flies trapped in epidemic areas.

IN HONOR OF DR. LIBERTY HYDE BAILEY

A GREAT palm glade on the shore of Biscayne Bay, Florida, is planned by the Fairchild Tropical Garden, Coconut Grove, Florida, in honor of Dr. Liberty Hyde Bailey, emeritus professor and formerly dean of the College of Agriculture of Cornell University.

It is anticipated that the glade of tropical palms, while serving as a permanent memorial to Professor Bailey, will be a mecca to thousands of garden lovers making pilgrimages to southern Florida to see what tropical palms really are.

Influential in the field of horticulture since the beginning of agricultural education in this country, Professor Bailey has devoted his life to conserving forests, improving rural schools, building departments of horticulture in colleges, bettering country life, stimulating plant selection and plant breeding, teaching landscape gardening for homes and through his "Hortus" and his "Encyclopedias," providing the plant lover with guides for determining the names of plants.

Professor Bailey in the last ten years has devoted attention to the palms, collecting them himself in the tropical jungles, classifying unknown sorts and building one of the world's best collections in the Bailey Hortorium in Ithaca, which he gave to the university.

It is planned to dedicate the Liberty Hyde Bailey Palm Glade on Dr. Bailey's eighty-fourth birthday, March 15, and to present him then with an album containing the names of all who have contributed. Dr. David Fairchild, retired U. S. Government botanist, the originator of the Fairchild Tropical Garden at Coconut Grove, Fla., is raising the funds for the palm glade. He is seeking nominal gifts "from the greatest possible number" of Dr. Bailey's friends and admirers. "To this end," Dr. Fairchild states, "it has been decided that no contribution shall be of more than one dollar."

Professor Bailey was born in Michigan. He attended the first agricultural college established near Lansing, Michigan. His affiliation with Cornell began in 1888 when he became professor of horticulture; from 1903 to 1913 he was director and dean of the College of Agriculture of the university. He has worked in the jungles of Central America, Mexico,

Cuba and other countries for his collections, the palm collection constituting one of the best in the world.

As a result of his support of the Fairchild Tropical Garden, of which he has been a member since its inception, the directors of this organization now have chosen to honor him with a memorial that is expressive of his great interest in the palm tree. To quote Professor Bailey's own words:

> The palms represent what is commonly considered to be the noblest family of plants; and yet they are to this day perhaps the least perfectly known, in general, of any of the great groups of vegetation. . . . The utility of palms is bound to take new directions and to increase, both as ornamental and interesting objects and as sources of important supplies.

THE MEMPHIS MEETING OF THE AMERICAN CHEMICAL SOCIETY

THE 103rd meeting of the American Chemical Society will be held in Memphis from April 20 to 24 under the presidency of Dr. Harry N. Holmes, head of the department of chemistry at Oberlin College. It is expected that more than 3,000 chemists will be in attendance. Sessions will be held by seventeen of the eighteen divisions, embracing practically every field of chemical science. Many of the papers will deal with chemical developments in the South and in the Memphis area. Numerous special symposia, devoted to recent progress in medicinal chemistry, vitamins, nutrition, agriculture and other fields have been arranged. Experts from all parts of the country will participate.

Reports before the divisions will describe the latest researches in rubber, petroleum, plastics, sugar, agriculture and food, gas and fuel, cellulose, water, sewage, and sanitation, paint and varnish, biological chemistry, analytical and micro chemistry, industrial and engineering chemistry, colloid chemistry, organic chemistry, physical and inorganic chemistry, chemical education and history of chemistry.

W. F. Bowld, general manager of the Buckeye Cotton Oil Company, Memphis, has been appointed general chairman of the convention committee. The honorary chairman is Dr. Victor A. Coulter, of the University of Mississippi. The following have been chosen vice-chairmen: L. N. Rogers, chemical director of the cellulose division, Buckeye Cotton Oil Company; E. R. Barrow, secretary-treasurer of Barrow-Agee Laboratories, Memphis; Paul D. Bowers, chief chemist of the Firestone Tire and Rubber Company of Tennessee; Thomas P. Nash, Jr., dean of the School of Biological Sciences at the University of Tennessee.

The Memphis Section of the society, of which Dr. Nash is chairman, will be host to the visiting chemists. Arrangements are being made at the headquarters of the society in Washington, D. C., under the direction of Dr. Charles L. Parsons, secretary and general manager of the society.

In addition to the professional sessions, meetings will be held by the Council and Board of Directors. Dr. Holmes will preside at the meetings of the council on Monday, April 20. Dr. Thomas Midgley, Jr., of Worthington, Ohio, vice-president of the Ethyl Gasoline Corporation, will preside on Sunday, April 19, at the meeting of the board, of which he is chairman.

Registration will begin on Sunday, April 19, at 2 P.M., in the Memphis Municipal Auditorium. The opening event of the convention will be a general meeting in the Auditorium on Monday, April 20, at 2 P.M.

A program of social and educational events has been arranged, including group luncheons and dinners. The dinner of the society will be given on Wednesday, April 22. Trips will be made to points of industrial and historical interest in the Memphis area.

SCIENTIFIC NOTES AND NEWS

THOMAS MIDGLEY, JR., vice-president of the Ethyl Gasoline Corporation and discoverer of tetra-ethyl lead, which has made possible great advance in automotive and aircraft engines, has been awarded the 1942 Willard Gibbs Medal of the Chicago Section of the American Chemical Society, in recognition of his "discoveries which are outstanding both from the standpoint of pioneering in new fields and from the standpoint of commercial importance." The presentation will be made at a meeting of the section on May 22.

THE 1941 Lawrence B. Sperry Award of $250 of the Institute of the Aeronautical Sciences has been given to Ernest G. Stout, engineer for the Consolidated Aircraft Corporation of San Diego, Calif., "for a notable contribution by a young man to the aeronautical sciences." The award was made in recognition of Mr. Stout's work in improving take-off and landing characteristics of flying boats and seaplanes. It was presented on January 27 at the honors-night dinner of the institute at the Hotel Waldorf-Astoria, New York City.

A COMMEMORATIVE volume prepared by a group of former graduates of the department of psychology of Stanford University was presented to Professor Lewis Madison Terman, since 1922 chairman of that department, at a dinner in honor of his birthday, given on January 15 by Judge and Mrs. William F. James.

The volume, "Studies in Personality, Contributed in honor of Lewis M. Terman," contains sixteen original research papers prepared by psychologists who in the past have worked under his direction. The papers range from studies of personality development and measurement to studies of psychical belief and abnormal phenomena. The volume includes an introduction by Professor Robert S. Woodworth, emeritus professor of psychology at Columbia University, and a bibliography of Professor Terman's writings. Editors of the volume were Dr. Maud Merrill James and Dr. Quinn McNemar, members of the faculty of psychology.

Nature reports that Professor Hermann Steudel, emeritus professor and director of the Institute of Chemical Physiology at Berlin, has been awarded the Goethe Medal for Art and Science on the occasion of his seventieth birthday.

AT the forty-fourth annual meeting of the Washington Academy of Sciences, on January 15, Dr. Harvey L. Curtis, of the National Bureau of Standards, was elected *president;* Frederick D. Rossini, of the National Bureau of Standards, *secretary,* and Howard S. Rappleye, of the U. S. Coast and Geodetic Survey, *treasurer.* Other officers for 1942 are as follows: *Archivist,* Nathan R. Smith; *Editors of the Journal,* Raymond J. Seeger, G. Arthur Cooper and Jason R. Swallen; *Custodian and Subscription Manager of Publications,* William W. Diehl; *Committee on Membership,* Frank C. Kracek, *chairman; Committee on Meetings,* Clement L. Garner, *chairman; Committee on Monographs,* Henry B. Collins, Jr., *chairman; Members of the Board of Managers,* John E. Graf, Frank H. H. Roberts, Jr., Ferdinand G. Brickwedde, Henry B. Collins, Jr., William G. Brombacher, Ernest P. Walker, Herbert L. Haller, Austin H. Clark, Alexander Wetmore, John B. Reeside, Jr., Fred O. Coe, Allen C. Clark, James E. McMurtrey, Jr., Aleš Hrdlička, William A. Dayton, Paul C. Whitney, Francis B. Silsbee, Walter Ramberg, Emmett W. Price, Leland W. Parr, Clement L. Garner, Herbert Grove Dorsey and Herman Stabler.

THE Association for Symbolic Logic announces the following elections: *Secretary-Treasurer,* for a term of three years, Dr. J. C. C. McKinsey, of New York University; as members of the *Executive Committee,* for a term of three years, Professor Paul Marhenke, of the University of California, and Professor Alfred Tarski; as member for a term of one year, Professor Arnold Dresden, of Swarthmore College. The council of the association has appointed Dr. J. C. C. McKinsey, of New York University, to be *Managing Editor* of the *Journal,* and has reappointed Professor Alonzo Church, of Princeton University, as *editor,* each for a term of three years.

AT the Dallas meeting of the Union of American Biological Societies, Dr. Anton J. Carlson, Frank P. Hixon distinguished professor of physiology, emeritus, of the University of Chicago, was elected president.

OFFICERS of the Entomological Society of America have been elected as follows: *President,* Dr. C. P. Alexander, Massachusetts State College; *First Vice-president,* Professor Miriam A. Palmer, Colorado State College; *Second Vice-president,* William T. Davis, Staten Island, N. Y.; *Secretary-Treasurer,* Dr. Clarence E. Mickel, University of Minnesota.

BRONISLAW K. MALINOWSKI, of Yale University, who now holds the position of Bishop Museum visiting professor of anthropology, has been appointed professor of cultural anthropology at the university, effective on July 1.

DR. RUSSELL F. SULLIVAN, of Brookline, Mass., has been appointed professor of orthopedic surgery at Tufts College Medical School. Dr. Sullivan was a graduate of the college in 1918.

DR. FRED W. RANKIN, of Lexington, Ky., president-elect of the American Medical Association, has been appointed chief consulting surgeon of the Army and will assume the post on March 1 with the rank of colonel. He is a son-in-law of the late Dr. Charles Mayo.

THE *Journal* of the American Medical Association reports that Dr. Lewis R. Thompson, Washington, director of the National Institute of Health and assistant surgeon general in charge of scientific research, has been appointed chief inspecting officer of the U. S. Public Health Service, a new position established in the Office of the Surgeon General. As a result of the increased demands on the Public Health Service because of the expansion of programs of civilian and military defense, the field activities of the district offices of the Public Health Service and its liaison officers in the army corps areas have been consolidated under one head. Dr. Rolla E. Dyer, chief of the Division of Infectious Diseases and assistant director of the institute, has been named to succeed Dr. Thompson as assistant surgeon general in charge of the Division of Scientific Research and as director of the National Institute of Health, effective on February 1.

DR. J. PERCY MOORE, research fellow of the department of mollusks and chairman of the library committee of the Academy of Natural Sciences of Philadelphia, has been elected a member of the Board of Trustees.

DR. RAYMOND G. SPENCER, formerly associate professor of physics at Albion College, has been ap-

pointed chairman of metallurgical research of the Armour Research Foundation.

DR. ALEXANDER FORBES, professor of physiology at the Harvard Medical School, has become the first president of the George Junior Republic Association, Inc., formed by a merger of the association and the Boy Conservation Bureau.

ACCORDING to a United Press dispatch, Dr. Karl Otto Heinrich Lange, instructor at Blue Hill Meteorological Observatory, Harvard University, formerly research physicist for the German Government, has been in Federal custody as an enemy alien since December 8.

PRESIDENT ROOSEVELT has appointed Dr. George Baehr, chief medical officer of the Office of Civilian Defense, to be a member of the Health and Medical Committee of the Office of Defense Health and Welfare Services. Dr. Irvin Abell, Louisville, Ky., chairman of the Committee on Medical Preparedness of the American Medical Association, is chairman of the Health and Medical Committee and other members are the Surgeon General of the U. S. Army, Major General James C. Magee; the Surgeon General of the U. S. Navy, Rear Admiral Ross T. McIntire; the Surgeon General of the U. S. Public Health Service, Dr. Thomas Parran, and the chairman of the Division of Medical Sciences, National Research Council, Dr. Lewis H. Weed, Baltimore. The Office of Defense Health and Welfare Services is a part of the Office for Emergency Management, which in turn is part of the Executive Office of the President. The director of the Office of Defense Health and Welfare Services is Paul V. McNutt, who is also Federal Security Administrator.

THE Hitchcock lectures of the University of California will be given by Dr. A. H. Reginald Buller, emeritus professor of botany at the University of Manitoba, during the month of February. The titles of the lectures are as follows: "Mushrooms and Toadstools as Organs for the Production and Liberation of Spores"; "Hyphal Fusions and Protoplasmic Streaming"; "The Sexual Process in the Rust Fungi"; "Recent Discoveries Concerning the Bird's-Nest Fungi."

DR. NORMAN JOLLIFFE, associate professor of medicine at New York University, a member of the nutrition committee of the National Research Council, gave the first of a series of lectures and discussions on nutrition on January 14 at the School of Education of New York University. The lecture was entitled "The Prevalence of Malnutrition."

Nature states that a dietetic council has been set up in Ireland under the leadership of Dr. P. T. Farrell to experiment on ways and means of aiding the people's nutrition under war-time conditions, paying special attention to the diet of children.

THE Mexican Embassy in Washington announces that the President of Mexico, General Manuel Avila Camacho, has issued invitations for an Inter-American Scientific Congress to be held in Mexico from February 16 to 26. Ambassador Castillo Najera said that scientific men and scholars from all the countries of the Western Hemisphere had been invited to attend, and that acceptances already had been received from thirty residents of the United States. The conference will coincide with the dedication of the new Mexican National Astrophysical Observatory at Tonanzintla, State of Puebla.

THE first Mexican Congress of Internal Medicine will be held in Mexico City from May 3 to 10, under the auspices of the President of Mexico and the Departments of Education and Public Health, with the cooperation of the medical societies of Mexico and the National University. The congress will be made up into various sections covering a wide range of subjects.

THE second Congress of Dental Education and Licensure, conducted by the Council on Dental Education of the American Dental Association, will take place at the Palmer House, Chicago, on February 21. Dr. Franklyn Bliss Snyder, president of Northwestern University, will make an address on "The University and Professional Education."

AT a recent meeting of the executive committee of the National Parks Association, the importance of carrying on its educational program was emphasized. It is planned to continue the advocacy of National Primeval Parks as a distinct category, to promote worthy park projects that have already been authorized, to encourage appreciation and the proper use of America's natural and historic heritage, to combat each threat of commercial encroachment upon protected reservations and to divert destructive uses of all kinds from superlative natural areas.

THE Bermuda Biological Laboratory for Research, Inc., has established scholarships for work in Bermuda for a limited number of special investigators. Although the original laboratory building is not available, working space with simple equipment and running sea water has been placed at the disposal of biological workers at the Government Aquarium through the kindness of its director, Dr. Louis Mobray. The scholarship stipend is intended to cover travel and living expenses. Should travel to Bermuda become impossible or inadvisable, scholarships might be awarded for work at a laboratory in some

part of the United States having a semitropical marine fauna or flora. Applications giving an outline of the proposed investigation, the place of proposed study and the time of stay should be sent to the Committee on Award, care of Dr. Columbus Iselin II, Woods Hole Oceanographic Institution; Professor Ross G. Harrison, Yale University, or Professor E. Newton Harvey, chairman, Princeton University.

APPOINTMENT for the year 1942–43 to the Charles W. Hargitt Research Fellowship in Zoology, at Duke University, will be made on March 15. The fellowship for post-doctoral work, carrying a stipend of $1,000, is restricted to research work in cytology; appointment is for a single year with the possibility of reappointment. Applications must be filed by March 1. Inquiries should be made to, and application blanks obtained from Dr. Geo. T. Hargitt, Biology Building, Duke University, Durham, N. C.

AFTER over thirty years of operation with a mechanically recording Wiechert seismograph, the Spring Hill College Seismological Observatory (Mobile, Ala.) began the New Year of 1942 with the installation of two sensitive photographic instruments. Two drum synchronous motor-driven recorders and two rebuilt McComb-Romberg tilt-compensating seismometers have been sent on indefinite loan to the observatory by the Franklin Institute of Philadelphia. The seismographs were used in Little America during the last Antarctic expedition of Rear Admiral Richard E. Byrd. The U. S. Coast and Geodetic Survey undertook to rebuild and increase the sensitivity of the instruments and assisted in placing them in operation. The seismologist in charge of the Spring Hill Observatory is Fr. A. J. Westland, S.J., who recently completed four years special study in seismology under the direction of Rev. Dr. J. B. Macelwane, S.J., director of the Institute for Geophysics at St. Louis University.

DISCUSSION

SEX-DETERMINATION IN MELANDRIUM AND LYMANTRIA

IN a series of reports Warmke and Blakeslee[1] announced the important discovery that in Melandrium the Y-chromosome contains the male-determining factors balanced against the female ones in the X-chromosomes, the autosomes playing hardly any role in the mechanism. This constitutes a mechanism identical with what I had considered for many years to be the situation in Lymantria (of course with M and F exchanged on account of female heterogamety, ♀ = XY or WZ). In Lymantria it is unequivocally proven that the male determiners (M) are located in the X-chromosomes and that the female determiners (F) are inherited maternally, the autosomes containing only secondary modifiers for femaleness. This maternal inheritance of F, confirmed in innumerable and decisive checks, may mean either cytoplasmic or Y-chromosome localization. I decided for the Y-chromosome when cases were found in which a weak female crossed to a strong male produced, in addition to sex-reversal males, a few exceptional females which turned out to be strong and inherited this character maternally. This excludes the cytoplasm and can be explained by non-disjunction and fertilization by an XXY male from the strong race. Thus I considered the location of F in the Y-chromosome as most probable and repeatedly discussed the consequences. Having for about 15 years accepted this solution, which was borne out by all available facts, I finally made up an experiment which I considered crucial.[2] The idea was the following: If F is located in the Y-chromosome, a sex reversal male produced by crossing a weak mother to a strong father is XY and therefore has a weak F in the Y-chromosome, a strong M in the X. Some of the daughters of such males derive their Y from the XY-father, which is then a Y with a weak F. This can be tested by crossing all daughters to strong males. If F is located in the Y-chromosome a part of the crosses will produce only males (half by sex-reversal). This experiment carried out with over 100,000 individuals never gave an all male brood. I considered this final proof in favor of the cytoplasm, though the above-mentioned data, explained by non-disjunction and location of F in the Y-chromosome, now became unexplainable, though the facts were found over again.

Blakeslee's new work suggests a need for reconsidering the situation: perhaps, after all, the old explanation was correct, and the sex-determining mechanism is the same as in Melandrium. To answer this question it is necessary to re-examine the experiment considered to be crucial, for a possible loophole. The test presupposes, first, that half of the F_1 individuals from all-male broods are XY, as had been found in previous work; second, that in the offspring of these males females are present which have been sired by

[1] See H. E. Warmke and A. F. Blakeslee, SCIENCE, 89: 1939, *et al.*

[2] R. Goldschmidt, *Ztschr. ind. Abstl.*, 67: 1934; *Bibl. genet.*, 11: 1934.

sex-reversal males. As 168 F_1 males were crossed and 365 daughters tested by recrossing with strong males, we assumed that XY-males could not have escaped detection. Actually 10 per cent. of the crosses with F_1 males were sterile. Now that Blakeslee's work focuses attention again on the Y-chromosome, the question has to be asked (not overlooked in the original paper) whether these sterile crosses were not the only ones sired by a sex-reversal male. If this were the case, the experiment would no longer be crucial. After Blakeslee's work I am inclined to this conclusion and to assume that my original conclusion as to the location of F in the Y-chromosome, backed by weighty experimental evidence, was the correct one. A decisive experiment could be planned, but its execution would require definite Japanese races of the gypsy moth, a condition which precludes a check for the time being.

RICHARD GOLDSCHMIDT
UNIVERSITY OF CALIFORNIA

MAN'S BIOLOGICAL FUTURE

THE discussion of man's biological future started by Blackwelder[1] and continued by Goodale[2] and Miller[3] still leaves much unconsidered. Blackwelder states the case thus (p. 365):

> Just as it would have been difficult for even a most intelligent trilobite to imagine the fish, which was destined to drive him from the scene, so it is not easy for us to forecast the nature and potentialities of that new species of *Homo* which may appear in the distant future—unless indeed our genus itself has by that time run its course and is not destined to offer the world anything further. . . . The only way in which he is likely to outstrip *Homo sapiens* effectively is in the quality of his brain.

To these pessimistic implications that man may not be able to hold his own against some hypothetical new species of *Homo,* Miller adds three further pessimistic implications, namely (1) man's giantism, (2) his racial old age and (3) his specialized type of social behavior; pessimistic because of the implication that specialization has proved dangerous in paleontological history.

To this, should be added the speculations of Howard,[4] who in comparing man with insects concludes (p. 5) that

> insects have had 12,500 times the chance that man has had to evolve a persistent type. . . . Man, then, is a newcomer. He may be a fugitive inhabitant of the world, speaking in geological terms, but . . . the possession of characteristics (insects) . . . would seem to assure their persistence even if such an experiment of Nature's as the human species should be found eventually to be an unfortunate and unsuccessful one. . . .
>
> It seems as though the insects were quite the most permanent and persistent type that life has evolved. . . . (p. 8) for the consideration of our present existence and of our relation to the forms of life that coexist with us it is not too much to assume that insects will be here when we are gone. I am inclined to think . . . that the last living thing on the globe will be some active insect sitting on a dead lichen which will represent the last of the life of the plants.
>
> But there may come a cataclysm, in which case the human species may be wiped out, . . . (p. 9) Tillyard has found in New Zealand a primitive caterpillar feeding on a liverwort . . . and this insect type appears to have remained unchanged for millions of years. What is a cataclysm or two to the insect class? . . . the insects have passed through cataclysm after cataclysm; and when they are subdued it will be safe for some possible historian in Mars to say "That is the end of that world."

To any possible objection about pessimism, Blackwelder has replied that a "scientist is under no obligation to be an optimist. His only concern must be to approach nearer to the truth." If truth offers hope, so much the better. Goodale offered hope that "man holds his biological destiny in his own hands." This, of course, assumes that man will direct his own evolution on the basis of his understanding of genetic principles.

But quite apart from man's control of his own evolution, there is evidence to indicate that man or his improved descendants will be able to cope with his competitive foes or forces of nature. The fact that man or his ancestors have been able to cope with and survive in face of all competition from longer persistent forms gives a ray of hope. His emergence from such competition to a dominating place among organisms where he has almost a monopoly on intelligence is positively encouraging.

The characterization of the present as an age of insects based largely on the enormous numbers both of kinds and individuals is scarcely tenable as an alternative to the age of man. It overlooks the fact that man's ancestors persisted in face of the opposition of the long established forms and gradually spread over most of the world, occupying nearly every terrestrial habitat suitable to his size despite the presence of insects or other animals already established there.

Primitive man having spread into nearly every part of the world, where he was confronted with varying environments, developed adaptations which met the differing conditions and produced differing races. Successful and prolific races sometimes over-ran less successful races and crowded them into oblivion. This

[1] Eliot Blackwelder, SCIENCE, 93: 359–366, April 18, 1941.
[2] H. D. Goodale, SCIENCE, 93: 618, June 27, 1941.
[3] Gerrit S. Miller, Jr., SCIENCE, 94: 163–164, August 15, 1941.
[4] L. O. Howard, "The Insect Menace." Century Company, 347 p.

appears to be the method of evolution. This interpretation is difficult to harmonize with Blackwelder's assumption (p. 365, line 9) that "new species originate not by gradual imperceptible changes, but by sudden mutations." His assumption leads to the idea that some new creature of human lineage will crowd out man, whereas, predicting from the past, man will probably evolve gradually via new Mendelian combinations, chromosome aberrations and gene mutations. There seems to be little chance for off-shoots to diverge from man.

What are the chances that some other species not of human stock may outstrip man? For comparative analysis, consider the birds. When they took to the air, they obtained a practical monopoly among vertebrates despite the prior claims of the pterosaurs and winged insects. With this monopoly, they were able to spread and differentiate into very successful groups. In doing so, they undoubtedly eliminated by competition many of the intermediate stages of development, so there are few forms left to indicate the steps in their evolution.

Man is in a similar position with his monopoly on intelligence. He was the first to develop it to the stage where it could be successfully applied to modification of his environment on a large scale. This environmental control is so enormous by comparison with other animals that he is transforming large sections of the world so as to produce increased density of his own population and his satellites at the expense of other creatures. In so doing, man seems, like the birds, to have crowded out intermediate forms, so there is now a large gap between man and his nearest primate relatives. But there is still a difference between the past divergent evolution of birds and the prospects for man. In contrast with birds which developed divergence in ecological isolation, man is now reversing the process. With his rapidly developing transportation facilities, he is tending to prevent isolation, thus providing more and more mixing of divergent hereditary characteristics of previously differentiated races.

With man applying his intelligence to the control of his biological competitors and with his biological destiny in his own hands (Goodale), it would seem that man has good cause to be optimistic despite the alleged dangerous specializations to which Miller called attention. There may be, however, enough generalized characters of man to nullify the purported dangers from such specializations. There seems to be nothing on the horizon in any direction which shows possibilities of taking leadership away from man or his descendants—certainly not the insects.

ANGUS M. WOODBURY

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DEMONSTRATION OF LABYRINTHULA PARASITE IN EEL-GRASS FROM THE COAST OF CALIFORNIA[1]

IN a recent publication of the U. S. Fish and Wildlife Service, Moffit and Cottam describe some current abnormalities in the feeding behaviors of brant along the Pacific Coast.[2] These appear to be related to the depletion of marine eel-grass, *Zostera marina*, that forms the preferred food of brant. Marked loss of the Pacific varieties of *Zostera marina* is limited to a few localities, and the condition is not comparable to the sudden wasting of Atlantic eel-grass in 1931.

At various intervals during the past year I have examined specimens of plants taken from affected beds without obtaining satisfactory evidence of parasitic activity. Recently, however, I received exceptionally well-fixed material in which I was able to demonstrate readily the *Labyrinthula* common to the diseased Atlantic eel-grass. The parasite was clearly present in two specimens collected from North Humbolt Bay, California, and from San Quentin Bay, Lower California. The beds from which they were taken were in good condition with few wasted plants. The *Labyrinthula* shows the same morphological features and peculiar distribution in recently invaded leaf tissue as in diseased leaves of Atlantic eel-grass.[3]

CHARLES E. RENN

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A SYSTEM FOR THE FILING OF REPRINTS

ALTHOUGH we are in sympathy with the recent request of Professor McCay[1] regarding standardization of size of reprints it is not likely that all journals will respond to his suggestion. In any event the change could not be retroactive, and hence we are faced with the problem of filing reprints larger than the usual sizes. The author has adopted recently a system, which may not be original, though I have not seen it used elsewhere, which gives promise of being satisfactory. The present file contains more than two thousand reprints and reports.

Discarding the usual boxes the system makes use of small metal cabinets. The particular cabinet chosen[2] contains 27 drawers, each measuring $3'' \times 9'' \times 12''$. In addition to accommodating the larger reprint sizes of which Professor McCay complains it is possible also to file typed reports ($8\frac{1}{2}'' \times 11''$). Of advantage

[1] Contribution No. 311 of the Woods Hole Oceanographic Institution.

[2] J. Moffit and C. Cottam, Wildlife Leaflet 204, November, 1941, 26 p. (mim.), Fish and Wildlife Service, U. S. Department of the Interior, 1941.

[3] C. E. Renn, *Biol. Bull.*, 70 (1): 148–158, 1936.

[1] C. M. McCay, SCIENCE, n.s., 94: 415, 1941.

[2] Obtained from Hobart Cabinet Company, Troy, Ohio.

also is the adaptability of these cabinets to otherwise unused space in the laboratory or office. They may be placed flat against the wall (and stacked one upon another in tiers) or at the ends of desks, tables, etc. Use of these cabinets likewise eliminates the necessity of shelving, and thus an empty room may be converted to a reprint file room without expensive carpenter work. The flexibility of the system allows the addition of small units as needed or budget may permit. In the event the collection requires moving it is an easy task to crate the individual cabinets; this also spares one of the unwelcome task of sorting and filing following the move.

The author prefers a subject filing system to an alphabetical author listing, since the material is of most value when thought of in relation to subject. Such a file (for example, a departmental collection) is then of value to graduate students or others who know the subject upon which they seek information but who, as yet, may be unfamiliar with the various authors. In my collection all reprints are marked by me in the upper right-hand corner in red ink to indicate the subject, thus permitting secretarial or other aid in filing. A typed list, which is posted, indicates the scope of each section, and thus the collection is available to others without my aid. With the modern trend to research by projects involving several persons rather than the isolated individual the need becomes emphasized of a single large file useful to the group.

In many instances (for example, reports relating to physiology, serology, taxonomy, etc.) there may be too many reprints relating to a certain subject to form a workable unit. For these a series of drawers is devoted to subdivisions of the larger topic which in the case of "physiology" include carbohydrate metabolism, nitrogen metabolism, lipolysis, effect of environment on microorganisms, etc. With the aid of a card file there is no worry that a reprint which relates directly to two or more subjects may be "lost" in the file since additional cards may be entered in the various subject divisions with each of the cards marked to indicate the placing of the reprint in the file. Since the card file contains countless references from the original literature and abstract sources those cards for which a reprint is available are so marked. The author has found no value in an alphabetical author listing of the reprints for general use, though perhaps such a compilation might be desirable for library holdings of a gift collection.

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PER CENT.

IF instructions in an original paper or a laboratory text-book call for, say, a 40 per cent. aqueous solution of caustic soda, it is probable that what is required is a solution containing 40 g of NaOH per 100 cc of solution, which is actually a solution containing about 30 per cent. NaOH by weight. Less probably, 40 g in 100 cc of water is actually meant, that is 28.6 per cent. by weight. Just possibly the author may really mean 40 per cent., that is, 40 g NaOH dissolved in 60 g of water. But, in general, no indication is given as to what is meant. There is often similar ambiguity in instructions for preparing mixtures of fluids when concentrations are stated as volumes per cent. With concentrations up to about 10 per cent., when accuracy is not required, the ambiguity is not important, but with stronger solutions misunderstanding may be critical.

It may be claimed that the custom of using the term "per cent." for grams or volumes per 100 cc solution is so well established in American scientific literature that nobody would be misled by it. However, the writer has been misled at times and the custom is confusing since it is not universally followed. For instance, bottles of concentrated hydrochloric acid are labeled with the specific gravity and the percentage acid, the percentage being given in the correct sense, that is, in grams acid per 100 grams of solution. The "Handbook of Physics and Chemistry" uses "per cent." only in the correct sense and uses specific statements for the other senses, see, *e.g.*, "Tables of Specific Gravity of Aqueous Solutions" and "Tables of Physical Constants of Compounds."

The incorrect use of "per cent." seems to be largely confined to writers in biological sciences, but there is no reason why workers in these fields should be content to use slipshod terms. I would like to recommend that authors, when stating concentrations of solutions, should indicate exactly what is meant, by using unambiguous expressions such as n g per 100 cc solution, of n g per 100 cc solvent, or n g in m cc solvent.

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SPECIAL CORRESPONDENCE

THE BRITISH GRAHAM LAND EXPEDITION, 1934–37

THE Graham Land Expedition was primarily engaged in survey work on the west coast of Graham Land and the adjacent islands, in the Falkland Island Dependencies, Antarctica. Advantage was taken of the exceptional opportunities for zoological research, and the resulting reports are being published by the British Museum. The following, dated August to October, 1940, have come to hand:

Vol. 1, No. 1, pp. 1–139. G. C. L. Bertram. "The Biology of the Weddell and Crabeater Seals."

Vol. 1, No. 2, pp. 141–194. Brian Roberts. "The Life Cycle of Wilson's Petrel."

Vol. 1, No. 3, pp. 195–254. Brian Roberts. "The Breeding Behavior of Penguins."

Vol. 1, No. 4, pp. 255–294. S. M. Manton (Mrs. J. P. Harding). "On Two New Species of the Hydroid Myriothela."

Vol. 1, No. 5, pp. 295–318. Theresa Clay. "Anoplura."

The reports are beautifully printed, but a good deal of space could have been saved by a different arrangement of the text, while the very wide margins are undesirable from any point of view, and especially now that there is a shortage of paper. There are four species of Antarctic seals, the Weddell and Crabeater being the most abundant, the former being a species of the coasts and inshore waters, the latter of the pack ice. The Crabeater has a misleading name, as its food is Euphausiid Crustacea, shrimp-like creatures of the plankton. Perhaps Floe-seal would be a better name, though the scientific name *Lobodon carcinophagus* can not be altered. During the course of the expedition it was necessary to kill 558 seals to provide food for 16 men and about 80 dogs. Dr. Bertram took every opportunity of doing the actual killing and butchering himself, in order to obtain the desirable records from each specimen. The records thus obtained, together with the concurrent observations of the living animals, give us an account of the biology of these seals which leaves little to be desired, and to this is appended a discussion of the behavior of the thirty living Pinnipedia of the world.

Wilson's petrel, which breeds in the Antarctic, is discussed at length by Dr. Roberts. Summing up, he says that the migration of this bird is one of the longest and perhaps the most remarkable of any bird known. In a straight line the Atlantic migration is about 7,000 miles in each direction yet the flight throughout is indirect and quite unlike that of land birds crossing the sea. For the greater part of eight months of the year most of them probably never come within sight of a landmark, yet they return at almost the same date each year to the same burrow and mate. "Oceanic migration of this type provides a noteworthy example of powers of endurance, and it also raises the problem of orientation in its most difficult form. In view of such facts it is extraordinary that visual memory is still quoted as the most satisfactory explanation of the way in which birds orient themselves during migration."

Four subspecies of Wilson's petrel are recognized, but they are separated on average characters, so that individual birds taken on migration can not be referred to any particular race with confidence. Dr. Roberts says, "the division into four races may not be useful for museum purposes," but he feels that it is desirable to have names for the different populations, which, when studied on their breeding grounds, do show average differences. It is interesting to find that Euphausiid Crustacea are the food of Wilson petrel as well as the so-called Crabeater seal. The parent petrels regurgitate partly digested *Euphausia* for the chicks, "in the early stages this takes the form of a clear oil," but some of the chicks were found to contain almost complete *Euphausia*.

The bird lice found on the Wilson's petrels proved to belong to a new species, which is described by Miss T. Clay as *Naubates robertsi* in her report on the Anoplura.

There are seventeen living species of penguins, which Dr. Roberts arranges in six families, one for each genus, except that the Adélie penguin is put in the same family as *Pygoscelis*. The present account has special reference to the Gentoo penguin, *Pygoscelis papua,* and gives a minutely detailed account, with many illustrations.

The author concludes that "each characteristic behavior phase appears to have little meaning unless considered in relation to its place in the cycle as a whole. There is a chain of stereotyped behavior acts correlated with physiological processes which are all closely related to each other. Bird behavior must surely be explained partly in physiological and partly in psychological terms, for endless difficulties arise through investigating by either method alone." All of which may be applied to other creatures than birds.

T. D. A. COCKERELL

UNIVERSITY OF COLORADO

SCIENTIFIC BOOKS

HARMONIC INTEGRALS

The Theory and Applications of Harmonic Integrals. By W. V. D. HODGE. ix + 281 pp. Cambridge, England: Cambridge University Press; New York: Macmillan Company. 1941. $4.50.

THE author of this monograph is one of the outstanding geometers in England, and in his special field—algebraic geometry—he is known, above all, for his important contributions to the theory of algebraic integrals attached to an algebraic variety (*abelian integrals*). This theory, inaugurated by the classical investigations of Abel and Riemann on the integrals

attached to an algebraic curve (1826, 1857) has been ever since the object of intensive study by analysts and geometers alike (Poincaré, Picard, Castelnuovo, Enriques, Severi, etc.) who were attracted to it either by its profound analytical content or by its power as a tool for the discovery of geometric properties of algebraic varieties. The theory gives rise to many difficult questions, and the difficulties increase with the dimension of the variety. Thus, while the theory of abelian integrals is almost a finished chapter in the case of algebraic curves and is a richly developed chapter also in the case of algebraic surfaces, it is on the whole unexplored territory in the case of varieties of higher dimension. The unsolved problems in which it abounds have to do mainly with the *classification* of the abelian integrals according to their singularities and with the properties of their *periods*. By the period of a *multiple,* say *m-fold,* abelian integral is meant its value which we obtain by integrating along an m-dimensional *cycle* of the variety (cycle = a closed m-dimensional region; a closed curve, if m = 1; a closed surface, if m = 2; etc.).

A typical and important problem, which remained unsolved for a long time, was the following: do there exist integrals which have no singularities and whose periods are all zero? Hodge was the first to prove that such integrals do not exist. This proof marks the beginning of a long series of investigations by Hodge which have materially contributed to a new and substantial progress of the theory of abelian integrals. One of the most significant aspects of these investigations is the diversity of the methods used. In addition to the purely analytical and algebro-geometric methods, topology and differential geometry come effectively into play.

Topological methods, already used by Poincaré in questions of the theory of algebraic surfaces, have been developed in this country by Lefschetz. The topological point of view in algebraic geometry plays an essential role in Hodge's solution of the problem mentioned above. Topology also forms the basis of de Rham's theory of integrals on arbitrary topological manifolds, a theory which is in close connection with Hodge's theory of harmonic integrals.

However, it is the adaptation of the methods and ideas of differential geometry (Riemannian geometry) to the theory of abelian integrals that best reveals the originality of Hodge's theory. Here the central concept is that of a *harmonic integral.* This is not the place to discuss this concept in any detail. It will suffice to say that the concept of a harmonic integral is more general than that of an abelian integral, but is more concrete than the concept of an integral attached to an arbitrary topological manifold. The fruitfulness of the concept of a harmonic integral lies perhaps just in its being a "harmonious" mixture of the right amounts of generality and concreteness.

The mathematical reader will find in Hodge's monograph a very well-written and highly stimulating account of a young and active mathematical theory. He will find ample evidence of the diversity of methods which we have mentioned above. As an ingenious blend of algebraic geometry, analysis, topology, tensor calculus and differential geometry, the monograph should prove of considerable interest to specialists in these various fields.

OSCAR ZARISKI

THE JOHNS HOPKINS UNIVERSITY

ELECTRICITY AND MAGNETISM

A Textbook in Electricity and Magnetism. By H. C. KELLY. vi + 356 pages. New York: John Wiley and Sons, Inc. 1941. $3.75.

THIS elementary text attempts to give the reader an acquaintance with a great deal of modern physics as well as to cover the conventional topics suggested by its title. The twenty-eight chapters are short and emphasize the historical and descriptive aspects of the subject. The diagrams are numerous and well drawn, and a number of simple problems are placed at the end of each chapter. In the third chapter the author goes to some pains to find the potential due to a point mass without the use of the calculus, but does not hesitate to introduce integration by the time Chapter 7 is reached, and to discuss the partial differential equations of the electromagnetic field and the wave equation in Chapter 28. In discussing induced electromotive forces the author makes the common mistake of attributing the e.m.f. to "*relative* motion between a wire and a magnetic field."

The book should prove very useful in a survey course intended to cover modern developments in physics as well as the elements of electromagnetism. To cite a few of the modern topics presented, we find mention of superconductivity, the Barkhausen effect, the Stern-Gerlach experiment, the cyclotron and the electron microscope, and discussions of space-charge, the photo-electric effect, the Bohr theory and the mass spectrograph.

L. P.

HYDROBIOLOGY

A Symposium on Hydrobiology. By JAMES G. NEEDHAM and 51 other contributors. ix + 405 pages. Madison: University of Wisconsin Press. 1941. Price $3.50.

THIS book contains the 32 formal papers presented at a symposium on hydrobiology held at the University of Wisconsin on September 4–6, 1940, and the abstracts of 16 volunteer papers given at one of the

sessions. The various contributions cover a wide variety of hydrobiological subjects relating to inland waters, including not only the biological aspects but also the geological, physical, chemical and sanitary phases of this field of science.

The limnological papers deal with the sediments of natural and artificial lakes, the penetration of solar radiation into natural water, dissolved oxygen and lake types, aquatic bacteria in relation to the cycle of organic matter in lakes, trematode parasites of fresh-water snails, the rôle of aquatic fungi in hydrobiology, the limnological rôle of the higher plants, the photosynthesis of algae, the relation of hydrological conditions to speciation in fishes, the age and growth of fresh-water fishes, the fish production of inland lakes and streams, pond fish farming and the effect of pollution on fish life.

The sanitary contributions relate to swimming pool sanitation, water-borne diseases, the chemical treatment of lakes, the food economy of certain mosquito larvae, the relation of hydrobiology to malaria control, the significance of plankton in relation to the sanitary condition of streams, schistosome dermatitis and its control, the microbiology of sewage and sewage treatment and the biochemical relations in the activated sludge process of sewage treatment.

Most of the contributions carry illustrations and include generous bibliographies.

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REPORTS

THE OUTLOOK FOR EDUCATION[1]

A RISING public anxiety respecting the economic difficulties of the after-war period is shared by all our institutions, public and private. Colleges and universities are expected to find their income greatly decreased. Will fewer and fewer students be enrolled as the private incomes of parents shrink in a post-war period of deflation? Will some institutions have to be closed? Will federal support be required for continuation and is it desirable to receive or solicit it? Will the individual members of our faculties come to be as meanly supported as those of continental Europe in the two decades following 1918? Will courses of study tend to become narrowly "practical"?

I believe there are American-style answers to be made to these timorous questions. The post-war period may witness surprisingly great industrial and commercial expansion to satisfy enormous reconstruction and delayed consumption requirements. It is too early to prophesy doom and it is a grave disservice to assume it. In any event we have a sound pioneer tradition in education whose hall-mark is democratic *experiment*. Whatever we may have borrowed from Europe in ideas, materials and techniques, we can trace definite lines of experimentation directed down the years toward our own conditions. The first of these conditions is that education must be adapted to a democratic way of life. Our educational system did not become inclusive by accident. It did not expand by accident. It was an indispensable part of the avowed design of America in the colonial period and still more emphatically at the beginning of our national life. The bulwark of democracy was to be an educated electorate. We are absolutely committed to that course. An illiterate people will not and can not be united. Our union, to be either effective or free, must rest on understanding, and as "no one can know it all or miss it wholly," discussion and compromise are indispensable. Education to know America, to know its history, its social life, its industrial expansion, its artistic and literary creations, its scientific achievements, its power to work together on so vast a scale and at so high a level of efficiency—all this, and all our defects and colossal shortcomings as well—make an educational program that the American public, in our opinion, will sustain. The after-war period will require, as earlier periods of crisis have required, that our cultural institutions keep asking and attempting to answer the question, "How do we want to live in America?" This is the question and the experiment that unites us. There are two deadly dangers in education, the unquestioning acceptance of routine in teaching, and complacency with respect to existing standards and objectives of research. The spirit that maketh alive is compounded in part of free inquiry and controlled experiment; in part also of a high dissatisfaction with the limits of yesterday's horizon.

After this war is ended, whether or not we participate, America will not be like any other country in the world. It will still have more mechanical and electrical power per person by several hundred per cent., it will have its commitments to democracy and inter-group habits of cooperation, there will still be private property and private incomes, there will be a characteristically American outlook in which enterprise, hope and hard work will be blended.

More advanced experimentation will probably mark our educational policies in the post-war years. How can we deepen the study, within the university, of great human problems whose solution is the surest guarantee of the future unity and freedom of Amer-

[1] From the annual report of Dr. Isaiah Bowman, president of the Johns Hopkins University.

ica? It is the crowning distinction of the American university that it has built a worthy part of the national temple. While there may be confusion in confused minds concerning university purpose, could anything be clearer than that free inquiry and report is itself one of the greatest and most highly moral educational purposes in a democracy? The university is not designed to be authoritarian and say the last word in morals, ideas, research or teaching. We can avoid the authoritarian road only by choosing the free road. A body of prescribed doctrine, approved books, dialectical smartness and *a priori* opinion masquerading as "wisdom" can give "unity" also, as authoritarian governments have amply demonstrated. The strength of our American unity is in our free way of uniting. Our purpose is to train that freedom into responsibility. The growth of our educational program is due to the demonstrated need for the trained and responsible men and women we help to produce, with all faults of training and learning fully and freely admitted. In part our directive principles and powers grow out of what we find, in part out of a high court of moral judgment called informed opinion. No earthly device can make all our people wise or infallible in judgment. Wisdom that serves unity and fair social living is not an affair of graven tablets to be memorized, nor yet a delusion based on "ragged notions and babblements," but experience of the individual with the world after some thought about human experiences as recorded in the books by minds that are trained to be critical. "Scientific method" is one of several ways by which such training may be developed. We are not far enough advanced biologically to get assured wisdom at 21, as a result of some final scheme of formal education that has so far eluded us according to the critics.

SPECIAL ARTICLES

PYRIDOXINE AS A GROWTH FACTOR FOR GRAPHIUM

PYRIDOXINE (vitamin B_6) is known to be essential for the growth of excised plant roots,[1,2] for certain mutant strains of *Neurospora*,[3] and for the G.M. strain of yeast.[4] In connection with our studies on the vitamin requirements of fungi, an interesting example of pyridoxine deficiency has been found in cultures of *Graphium ulmi*, the organism which causes Dutch elm disease. This preliminary report on *Graphium* presents an example of the requirement of an accessory growth factor necessary for the life of a parasitic fungus. In view of recent work on chemotherapy by use of analogs which compete with natural growth factors in certain microorganisms causing diseases, it is hoped that this information may be of some use to phytopathologists who are attempting to control the Dutch elm disease.

The basal solution used for cultivating *Graphium* contained the following in one liter of triple distilled water: recrystallized asparagine, 4.0 gm; dextrose, 40 gm; KH_2PO_4, 1.5 gm; $MgSO_4 \cdot 7H_2O$, 0.5 gm; $CaCl_2 \cdot 2H_2O$, 0.1 gm. The elements, B, Mn, Zn, Cu, Mo and Fe were supplied in appropriately small quantities. Vitamins were added to this medium in the following amounts per liter: thiamin, 300γ; lactoflavin, 100γ; nicotinic acid, 500γ; pyridoxine, 200γ; inositol, 500γ; pantothen, 200γ; biotin, 0.4γ; and ascorbic acid, 500γ. The medium was dispensed into pyrex flasks, 25 ml per flask, and autoclaved at 15 pounds for 20 minutes. Inoculation was accomplished with bacteriological precautions by pipetting a drop of spore suspension into each flask. Growth was determined at the end of two weeks by weighing the washed and dried mycelium on filter paper.

A typical experiment was set up with basal medium to which no vitamins were added, basal medium containing the 8 vitamins, and a series of media in which one vitamin was omitted at a time to give 8 kinds of single deficiencies. Five replications were employed for each kind of medium. Growth was obvious only in the media containing pyridoxine. The presence or absence of the other accessory substances made little difference in growth. In another experiment each of the 8 vitamins was added singly to the basal medium in order to determine the effectiveness of each in the absence of the other 7 accessory factors. Growth occurred only in the medium which contained pyridoxine. It appears that *Graphium* is able to grow in the basal medium supplemented with only pyridoxine. Either these other vitamins are not essential, or what is more likely, the fungus synthesizes out of elementary compounds other factors which are necessary for growth.

TABLE 1

Pyridoxine gamma/liter	Dry weight of *Graphium* mg/flask
0.005	0.2
0.01	0.3
0.1	1.5
1.0	4.5
50.0	14.2
500.0	13.5

[1] W. J. Robbins and M. B. Schmidt, *Proc. Nat. Acad. Sci., U. S. A.*, 25: 1, 1938.
[2] J. Bonner, *Amer. Jour. Bot.*, 27: 692, 1940.
[3] G. W. Beadle and E. L. Tatum, *Proc. Nat. Acad. Sci., U. S. A.*, 27: 499, 1941.
[4] R. J. Williams, R. E. Eakin and J. R. McMahan, University of Texas Publication 4137: 24, 1941.

Further studies on the extent of growth in basal medium supplemented with increasing amounts of pyridoxine gave the results shown in Table 1 expressed as the average dry weight of five flasks for each treatment.

The fungus is sensitive to increments of pyridoxine at least in the range from 0.01 to 50.0 gamma per liter. No claim is made for a complete medium for growth of *Graphium*. Additions of yeast or of dark molasses to the medium containing pyridoxine permits still greater growth of the fungus. It seems probable that other unidentified essential factors may be made by the fungus in less than optimum amounts for growth in this synthetic medium.

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ELECTROPHORESIS OF THE CHLOROPHYLL–PROTEIN COMPLEX

A NUMBER of reports concerning the isolation and purification of a chlorophyll-protein complex from leaves have recently appeared. Although the protein nature of the material composing the complex has been supported by analytical evidence, it seemed desirable to investigate the problem by means of electrophoresis in an attempt to demonstrate the existence of an isoelectric point in the range of pH characteristic of proteins.

In 1912 it was observed by Herlitzka,[1] on subjecting press juice of leaves to electrophoresis, that the chlorophyll migrated toward the anode. More recently, Neisch[2] has reported that suspensions of chloroplast granules isolated from clover leaves are electrophoretically negative in distilled water and positive in N/5 HCl. Aside from these reports, there seems to be no information in the literature concerning the electrophoresis of the purified chlorophyll-protein complex.

We have prepared suspensions of the complex by a modification of the methods of Menke[3] and of Stoll and Wiedemann.[4] Young leaves of beans (*Phaseolus vulgaris* L., var. white navy) were ground in M/100 phosphate buffers at pH 7.2 and the deep green suspension was centrifuged to remove cellular debris. Neutralized ammonium sulfate was added to the supernatant solution until the molarity reached 1.3. After a wait of thirty minutes the green material was sedimented by centrifugation; this left the brown impurities dissolved in the supernatant. The operation of resuspension in the buffer and subsequent salting out was repeated several times in the course of several hours. The green material was finally resuspended in the buffer and dialyzed against the same buffer until free from sulfate. All preparative operations were carried out at 0° C. The purified green suspensions exhibited the physical characteristics described by other workers,[4, 5, 6] *e.g.*, a strong maximum absorption band at about 678 mμ, photostability, red fluorescence, sensitivity to protein coagulants. When the pH was reduced below 5, flocculation ensued.

Using a microelectrophoresis technique which has been described elsewhere,[7] we have found that the green microscopic particles, which make up the suspensions, are isoelectric at pH 4.7 in M/50 acetate buffers at 25° C. The particles migrate independent of size, shape or degree of clumping. Particles at the limits of microscopic visibility (at a magnification of 1,100) migrated at the same rate as larger ones. In fact, the particles behaved as though their surfaces were exceedingly uniform. By centrifugation at about 4,000 r.p.m. it was possible to remove all visible particles. Quartz or collodion particles placed in the resultant clear green solutions exhibited an electrophoretic behavior identical, within the limits of error, with the natural chlorophyll-containing particles of the original suspensions. No significant differences could be noticed between the electric mobilities of various preparations. Under the above ionic conditions the electric mobility curve tends to flatten out on the negative side at about pH 6.5 and on the positive side at about pH 3.6.

Smith[6] reports that suspensions flocculated at pH 4.5 or below are altered by the acid and more readily salted out after resuspension. We have found that particles from suspensions exposed to a pH of 3.1 (M/25 acetic acid) for more than thirty minutes exhibit an altered electric mobility when resuspended in more basic buffers. The electric mobility curve is shifted so that the isoelectric point lies at pH 5.0. The curves are nearly parallel on the negative side but converge on the positive side. Investigations of the rate of this denaturation process show that it is virtually complete within five to ten minutes at pH 3.1 (at 25°). At values of pH more basic than 3.1 the process is less rapid. Since at least five minutes are needed to make a measurement of electric mobility, it is apparent that the electric mobility of the undenatured material can not readily be determined below pH 4.5. In this respect the particles are similar to thyroglobulin in their behavior.[8]

1 A. Herlitzka, *Biochem. Z.*, 38: 321, 1912.
2 A. C. Neisch, *Biochem. Jour.*, 33: 293, 1939.
3 W. Menke, *Z. Bot.*, 32: 273, 1938.
4 A. Stoll and E. Wiedemann, *Fortschr. Chem. organ. Naturstoffe*, 1: 159, 1938.
5 J. Shafer, SCIENCE, 91: 580, 1940.
6 E. L. Smith, *Jour. Gen. Physiol.*, 24: 565, 1941.
7 L. S. Moyer, *Jour. Bact.*, 31: 531, 1936.
8 M. Heidelberger and K. O. Pedersen, *Jour. Gen. Physiol.*, 19: 95, 1935.

It would seem premature to assert that these observations characterize the chlorophyll-protein itself. In any event, the electrophoretic properties are closely correlated with the general colloidal behavior of the complex. We intend to publish an extended account of these investigations in the near future.

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EFFECTS OF OXYGEN ON RESPIRATION, FERMENTATION AND GROWTH IN WHEAT AND RICE

RICE seeds are capable of germinating in the absence of oxygen and the seedlings grow well when submerged in water containing little oxygen, whereas wheat is unable to germinate or develop under such conditions.[1] In an attempt to ascertain the physiological basis for this difference, a study was made of the influence of variations in oxygen tension (pO_2), from 0 to 20.8 per cent., on respiration, fermentation and growth in seedlings of each of these cereal grains.

Manometric measurements of the gas exchanges occurring in seedlings of wheat (*Triticum vulgare* var. Leap's Prolific) and of rice (*Oryza sativa* var. Early Prolific) were conducted at 30° C., using a Barcroft-Warburg apparatus according to the method of Dickens and Simer.[2] The seedlings had roots 5 to 8 mm long when germinated in the dark at 30° C. on moist filter paper; for this development wheat required 24 to 26 hours, rice 30 to 33 hours. Groups of uniform seedlings (25 wheat or 30 rice) were soaked for one hour in a 0.013 molar phosphate buffer adjusted to pH 5.8, containing 4 per cent. sucrose and having a K/Ca balance of 7.5/1. Then the seedlings of each group were placed on a bed of glass beads in the manometer vessel with their roots submerged in the buffer solution to a depth of 1 to 2 mm. Prior to each test of 1 to 1.5 hours' duration, the vessels were thoroughly flushed with the required gas mixture, prepared by partially replacing normal air with nitrogen.

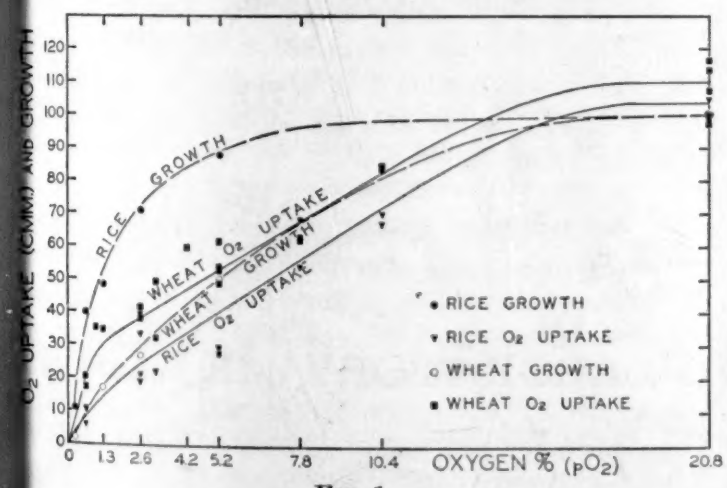

FIG. 1.

The results of the gas-exchange measurements are shown in Figs. 1 and 2, in which smoothed curves have been drawn in solid lines to show the trend of the experimentally determined points, each of which represents the average of 4 or 5 separate determinations. In 20.8 per cent. O_2 (air) the average activity of rice seedlings, as shown by CO_2 evolution, was found to be 87 per cent. of the average of wheat seedlings on the basis of dry weight of embryos. To facilitate comparison of the experimental data, the curves in all cases have been plotted for the activity of a number of seedlings (wheat, 6.4; rice, 13.3) calculated to produce 100 cmm of CO_2 per hour in 20.8 per cent. O_2.

In the growth experiments 225 twelve-hour-old seedlings of wheat and rice were allowed to develop

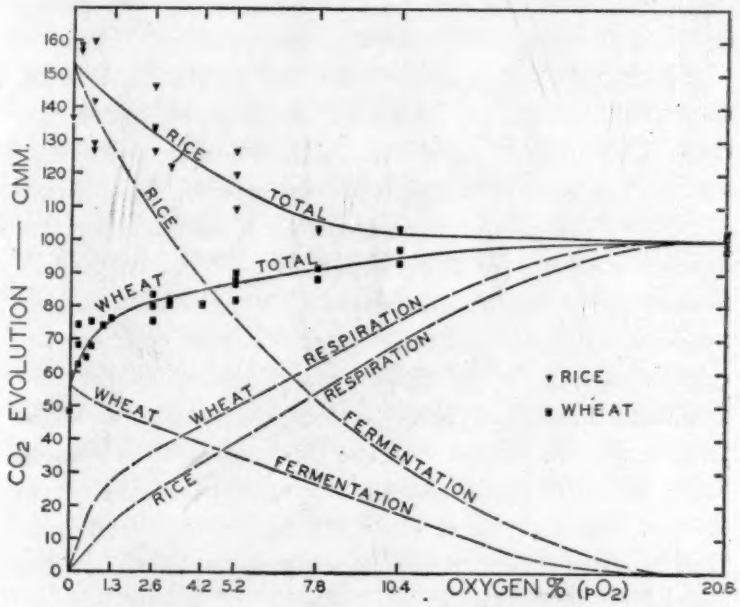

FIG. 2.

for 96 hours at 30° C. on moist filter paper in gas streams containing from 0.25 to 20.8 per cent. O_2. Increment in dry weight of embryo (*i.e.*, of all the seedling except the endosperm) was used as a measure of growth. The curves depicting the results of the growth experiments are presented in Fig. 1, plotted on a scale of ordinates in which 100 represents the increment in embryo dry weight in 20.8 per cent. O_2.

Inspection of the curves of Fig. 1 for O_2 consumption reveals the following relations: The O_2 intake by rice is less rapid than that by wheat over the range of O_2 tensions in which tests were conducted. With decrease in O_2 tension, the growth curve for wheat

[1] I. Nagai, *Tokyo Imp. Univ. Jour. Coll. Agr.*, 3: 109, 1916. C. Stich, *Flora*, 74: 1, 1891.

[2] M. Dixon, "Manometric Methods," pp. 61–67. London: Cambridge University Press. 1934.

falls rapidly, and it roughly parallels the curve for O_2 consumption. In rice the relation is very different: As the O_2 tension is decreased, the growth curve remains relatively high in spite of a rapid and continuous decrease in the O_2 intake.

Fig. 2 shows not only total evolution of CO_2, but also its components—respiration CO_2 and fermentation CO_2. In preparing these curves, it was assumed that all the activity of seedlings tested in 20.8 per cent. O_2 (air) was respiration (aerobic) and that in this O_2 tension little or no fermentation (anaerobic) occurred.[3] The respiratory quotient (CO_2/O_2) for activity in air was calculated, and it was assumed that this quotient remained constant for respiration (aerobic) in all O_2 tensions. Knowing the respiratory quotient, and having measured O_2 absorption and CO_2 evolution over the range of O_2 tensions, the amounts of respiration CO_2 and fermentation CO_2 could be calculated for any O_2 tension as follows:

cmm O_2 × respiratory quotient = cmm respiration CO_2.
cmm total CO_2 − cmm respiration CO_2 = cmm fermentation CO_2.

Applying this method to the smoothed curves for total CO_2 (Fig. 2) and O_2 (Fig. 1), the curves shown by broken lines in Fig. 2 were obtained.

From Fig. 2 it may be seen that as the O_2 tension decreases, the experimentally determined curve for total CO_2 output of wheat falls, whereas there is a rise in the corresponding curve for rice. The curves for CO_2 produced in respiration (aerobically) are similar in form to the O_2 activity curves of Fig. 1 from which they were calculated; wheat shows higher respiratory activity than rice. Inspection of the curves of Fig. 2 representing CO_2 produced in fermentation (anaerobically) shows far greater activity in rice than in wheat. As the O_2 tension is decreasing from 10 to 0 per cent., the fermentation in rice increases rapidly, until the CO_2 output by fermentation in 0 per cent. O_2 reaches 150 per cent. of the total CO_2 evolution in air. With the corresponding decrease in O_2 tension the increase in fermentation in wheat is much more gradual, and in the complete absence of O_2 the CO_2 output attains a level only 50 per cent. as high as the total CO_2 output in air.

Approximate I/N ratios (total CO_2 output in N_2 ÷ total CO_2 output in 20.8 per cent. O_2) for wheat and rice are 0.5 and 1.5, respectively; and Meyerhof quotients[4] for O_2 tensions above 0.25 per cent. are from 1.5 to 2.0 for rice and 0.2 to 0.5 for wheat. Both the I/N ratios and the Meyerhof quotients indicate that a marked Pasteur effect (or O_2 inhibition of fermentative processes) occurs in rice, whereas this effect is relatively weak in wheat. Under the conditions of these experiments the anaerobic mechanism of rice in the complete absence of oxygen is approximately three times as active as that of wheat. With increase in O_2 tension, the values of the F/R ratio (ratio of fermentation to respiration where O_2 is present, 0.25 per cent. or higher) range from 7.3 to 0 for wheat and from 50 to 0 for rice.

We may conclude that in the absence of O_2 rice is capable of germination because it possesses a strong mechanism for fermentation, whereas wheat, with its feebly functioning anaerobic system, is unable to germinate. Even in rice, growth soon ceases in the complete absence of oxygen. With a very low O_2 supply rice is able to accomplish more nearly normal growth than wheat in spite of the fact that rice is less capable than wheat of using the low concentration of O_2 in respiration. The superiority of rice over wheat in ability to grow in a low O_2 concentration is dependent upon the possession by rice of a very strongly developed fermentation (anaerobic) system that more than compensates for a respiration (aerobic) system that is even weaker than that of wheat. It is expected that a more detailed analysis of these data will be published elsewhere.

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[3] D. Burk, Cold Spring Harbor Symposia on Quantitative Biology, 7: 420, 1939.

[4] K. C. Dixon, *Proc. Cambridge Phil. Soc.*, 12: 431, 1937.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN APPARATUS TO DELIVER A MEASURED AMOUNT OF CO_2 FOR BLOOD CULTURES

THE importance of blood cultures in the diagnosis of Brucellosis in man necessitates a simple apparatus for providing a CO_2 atmosphere for these cultures. The apparatus described here (Fig. 1) can be made from materials usually stocked in any hospital laboratory.

The CO_2 is drawn from a tank with a reducing valve and conducted through a rubber tube to a three-way valve, and from this to either a hypodermic syringe or a Luer observation tube connected to a 20-gauge, 3-inch hypodermic needle. This needle has been bent and fused to a 20-gauge, 1½-inch needle, which in turn is fastened to another Luer observation tube opening to the outside. The three-way valve may be adjusted so that the barrel of the hypodermic syringe is connected with the tube leading to the longer hypodermic needle.

The three-way valve is first adjusted so that a stream

of CO_2 will flush out any air present in the rubber tubing and the 3-inch hypodermic needle. The needles are then inserted through the rubber vaccine stopper into the 250 cc medicine bottle containing 100 cc of medium, and 10 cc of the patient's blood. The valve is then turned so that the CO_2 will flow into the syringe, pushing up the plunger until the required amount is indicated on the barrel. The valve is once more adjusted so that the CO_2 will flow from the barrel of the syringe into the medicine bottle, displacing

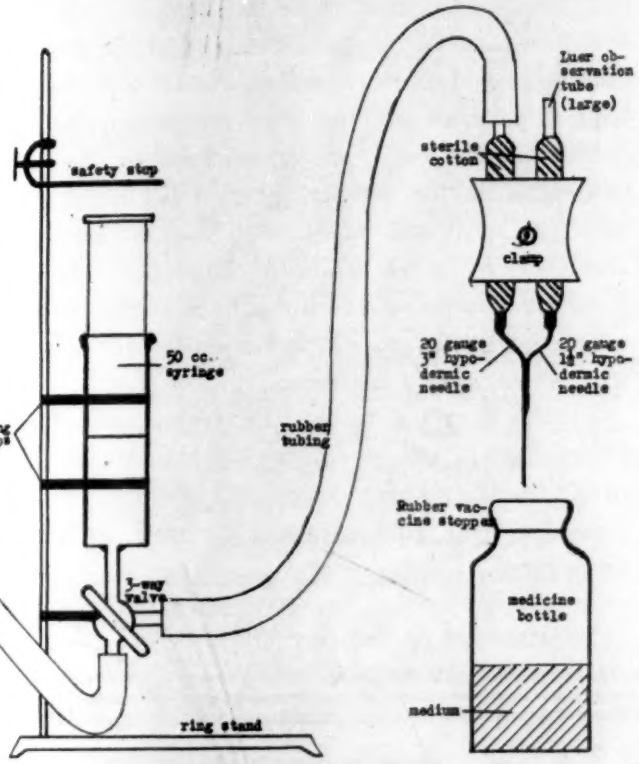

FIG. 1.

air which is forced from the bottle through the shorter hypodermic needle.

The weight of the plunger is sufficient to force the CO_2 out of the syringe if the plunger slides smoothly. Only a smoothly sliding syringe should be used if the volume is to be accurately measured. A safety clamp above the plunger will prevent it from shooting out when the CO_2 pressure becomes greater than the required ½ pound gauge pressure.

The three-way valve may be fused to the syringe or it may be fused to a collar which slips on the syringe. The latter is preferable since syringes of different sizes may then be used. The apparatus can then function in other ways. For example, without the needles, it may be used for conducting a measured amount of O_2 into an anaerobic jar during the preparation of staphylococcus enterotoxin. It may also be used to supply CO_2 to anaerobic jars for the culture of the gonococcus on solid media.

The needles may be sterilized as a unit together with the clamped Luer tubes.

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TRAPPING SNAILS OF THE GENUS CAMPELOMA

AN efficient method of collecting the snail *Campeloma* sp. in streams was found during a study of the life history of the trematode worm *Cercariaeum constantiae* Mueller. Since *Campeloma* habitually burrows, the collection of these snails in quantity by screening consumes much time and is hard work. While collecting these snails in the Huron River near Ann Arbor, Michigan, I noted that they were frequently found in considerable numbers around dead and decaying organic matter. To determine the time required to accumulate a quantity of snails, a dead fish weighing a pound was placed in the mud where earlier collections had been made. Ten days later, an area of approximately one foot square and six inches deep around the fish yielded 78 *Campeloma*, a number far exceeding those taken in similar, but unbaited, situations.

Dr. G. R. La Rue suggested the use of dung in place of dead fish, as he believed that these snails might be coprophagous and become infected by eating trematode eggs voided in feces. Accordingly, small cloth packets of feces were planted in the muck and found to be equally as effective as the dead fish, and more conveniently handled. Dung of dog, cat, ferret, muskrat and chicken was tried. After a few preliminary experiments, chicken dung was used exclusively. It was dried before use, which eliminated objectionable odors and permitted it to be packaged in quantity and stored to be used as needed. Dried dung was as effective as fresh.

To make a snail trap, a quantity of dried chicken dung is placed in the center of a cloth nine inches square, the corners twisted together and tied with heavy cotton twine, leaving free enough to tie to a stake. Double thickness of washed cheesecloth is ideal; heavier cloth resists rotting for a longer time but also retards the passage of the fecal extract. The twine should be capable of resisting rotting in water, since these packets remain effective until their contents are gone. The packets are tied to stakes and placed in suitable habitats for *Campeloma*.

Choice of location is important. In streams these snails frequent shallow, mucky situations and plantings should be made here; gravel areas in deep water should be avoided. When properly planted, the packet should be half-buried in mud with the stake projecting above the water level far enough to be easily recognized. In areas frequented by many people, the plantings should be inconspicuous to prevent possible interference. This can easily be accomplished by using dark-colored cloth and stakes made of tree branches; in summer, willow is especially suitable because the leaves remain green and willow looks natural along the banks of streams.

The trap remains effective for approximately six weeks, but to get best results the location should be changed every ten days or two weeks. The snails are collected by removing the trap and screening the mud from an area about 15 inches square around it by means of a wire net (Fig. 1). The net consists of a frame of one quarter inch steel bar fashioned in the shape of an equilateral triangle one foot on a side, and having a tang three inches long at the apex mounted in a handle with a ferrule. Galvanized wire screen of three sixteenths inch mesh is soldered to the frame. The screen gradually deepens from the leading edge to form a bag two inches deep at the apex of the triangle. The leading edge is protected by a band of galvanized sheet iron three inches wide folded over the frame and soldered. The completed screen is very sturdy and will withstand hard usage.

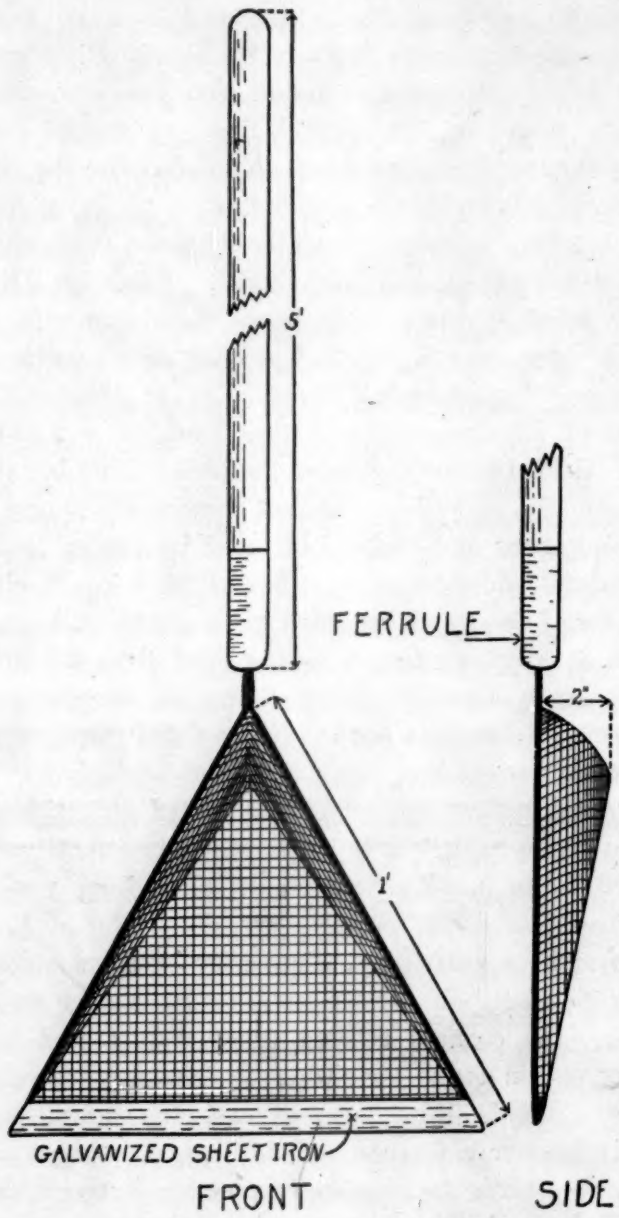

FIG. 1. Front and side view of collecting net.

It was suspected that in streams the current might carry the fecal extract which the snails followed to its source at the trap. This idea was tested by planting marked snails at various distances, two to 15 feet, upstream, as far as 20 feet downstream, and ten feet across the stream from a trap. In collections made at weekly intervals for five weeks, 28 of the 67 snails (41.7 per cent.) planted upstream, 24 of the 86 (26.7 per cent.) planted downstream, and 2 of the 9 (22.2 per cent.) planted across the stream were taken at the trap. Practically the same number of snails moved to the trap from 15 feet upstream and 20 feet downstream as from 2 feet up- and downstream. My data indicate that the snails move at random. Once arrived at the trap, however, they tend to stay as long as the food supply lasts.

In lakes the traps proved ineffective. Experiments to determine the reason for this have not been carried out. All the lakes tried had bottoms of sand underlaid by muck which perhaps provides sufficient food for *Campeloma* to nullify the effects of food concentrated at traps. Traps should be tried in lakes with clean, sandy bottoms.

In the streams tested the traps are specific for *Campeloma*. Other species of snails are not taken in the traps and only occasional bivalves, *Alasmidonta calceolus* and *Sphaerium* sp., have been collected from them.

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BOOKS RECEIVED

BARBER, HERVEY H. and T. IVAN TAYLOR. *Semimicro Qualitative Analysis.* Pp. xvi + 446. Harper. $3.50.

DAVIS, HAROLD T. *The Analysis of Economic Time Series.* Monograph No. 6, The Cowles Commission for Research in Economics. Pp. xiv + 620. Principia Press.

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FREEMAN, WALTER and JAMES W. WATTS. *Psychosurgery.* Illustrated. Pp. 237. Charles C. Thomas. $6.00.

GILMAN, HENRY. *Organic Syntheses.* Collective Volume 1, Revised edition. Pp. xi + 580. John Wiley. $6.00.

GREEN, S. L. *Algebraic Solid Geometry.* Pp. 132. Cambridge University Press. $1.75.

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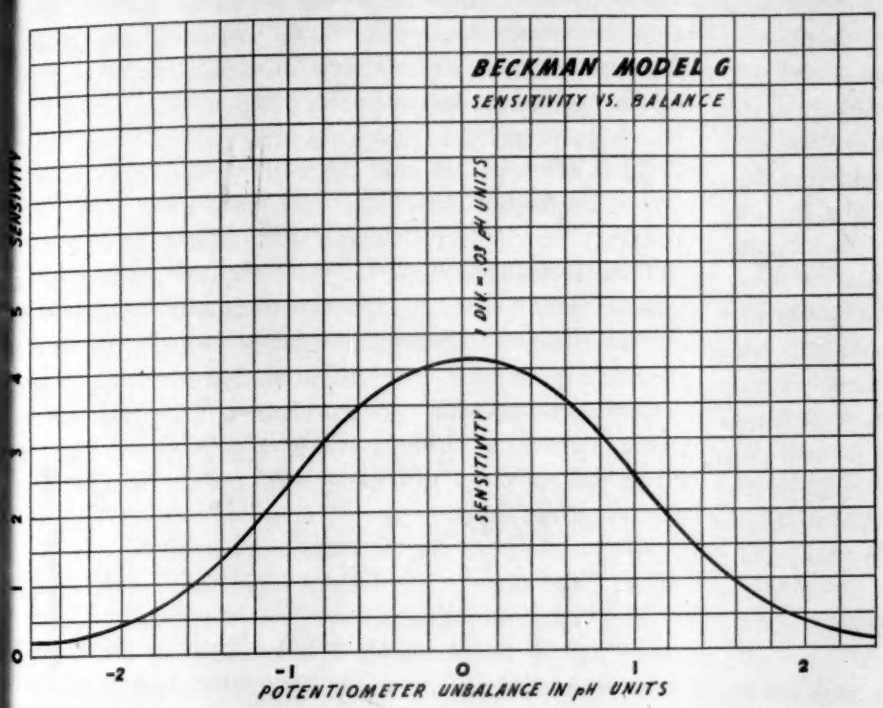

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SCIENCE NEWS

Science Service, Washington, D. C.

WARFARE AMONG ANTS

WAR at sight is not the rule in the ant world but rather the exception, despite wide-spread belief to the contrary, according to Dr. Laurence J. Lafleur, of New York City. When two stranger ants meet, instead of instantly beginning battle, they usually merely back off, turn aside a little, and go their respective ways. He states in a communication to the *American Naturalist* that "Except when slave-making ants make raids on their neighbors, and when spring competition for extra land causes wars, the ants of the northern states are a peaceful lot."

Even the slave-making species are not necessarily murderous in their raids, Dr. Lafleur points out. He cites the observation of the late Professor William Morton Wheeler, of Harvard University, who watched such a raid in progress. Slave-making ants in such raids are concerned only with the pupae or immature infants of the species they kidnap and carry off to be their servants. In the attack described by Dr. Wheeler, the marauders, much bigger and stronger than their victims, nevertheless did not kill them, but only carried the defenders out of the nest and set them down outside, uninjured.

Another struggle described by Dr. Lafleur was over a herd of aphids or "ant cows," whose sweet body-secretion is much prized by many species of ants. Although two rival ant armies were staging a rough-and-tumble contest, they refrained from tearing each other to pieces. Some of them even took time out to go and "milk" the aphids.

In still other cases, groups of stranger ants, even of different species, were forcibly mixed to see what they would do. Sometimes they fought for a while, then became a united, cooperating group. Sometimes the cooperation ensued without any preliminary fighting.

WILD RUBBER ON WASTELANDS IN THE WEST

MORE than 25,000 tons of wild rubber is hidden in the stems and roots of rabbit brush, a weed that grows thick on alkali flats and other wastelands of the West, according to Professor T. Harper Goodspeed, of the University of California. He has called attention to this unutilized resource in messages to the Federal Government and to the Governor of California.

Rabbit brush is a shrub, whose various species grow from knee-high to twice the height of a man. Its rubber occurs in the form of solid bits and shreds embedded in the tissues, as it does in its better known botanical relative, guayule. Hence, the same methods of harvesting and processing could be used that have been successful in extracting guayule rubber. It is not claimed that rabbit-brush rubber could compete with the East Indian product under normal conditions. It is not quite so high in quality, and it costs more to prepare; Professor Goodspeed estimates about 45 cents a pound. However, in the present emergency it might be worth while despite relatively high costs.

Estimates of the amount of rabbit-brush rubber that might be eventually harvested range all the way from a low of 10,000 tons to an extreme high of 250,000 tons. Certainly the sixteen major species of the shrub cover an immense area, from southern California to the northern Rockies. Some of them grow on alkali lands completely useless for any other purpose. Others have moved in as weeds on rangelands that have been seriously over-grazed.

The most practicable harvesting method, probably, would be to pull the plants up by the roots, using teams or tractors. This is because a considerable part of the rubber is embedded in the roots. The same uprooting process would serve to clear the range, permitting native grasses to grow again and thereby prepare the way for increasing another war resource, the meat and leather supply. Along with the rabbit brush, several other related rubber-containing weeds could be uprooted and processed, notably two genera known as Acraderica and Aplopappus.

The rubber of the rabbit brush is known as chrysil rubber, the name being derived from the plant's botanical title, Chrysothamnus. This comes from two Greek words meaning "golden bush." The name is well bestowed, for when it is in bloom every twig on the plant ends with a brush of beautiful, goldenrod-like flowers. Like guayule, rabbit brush is a member of the composite family, which includes goldenrods, dandelions, asters, sunflowers and the sinful, sneeze-causing ragweeds.

BLIND LANDING OF AIRPLANES

BLIND landing of airplanes is facilitated by a new invention using a low-power low-frequency transmitter, thus making for economy in the use of power, and useless to enemy planes not equipped with the device. The inventor is William Lee Clemmer, of Monroe, Wisconsin, who has been granted U. S. Patent 2,269,437.

The invention enables an aviator to fly into the neighborhood of a landing field at a safe high altitude, say 6,000 feet, and then spiral down until he has reached an altitude from which he can glide on to the field at a safe gliding angle. This the device makes possible by indicating continuously on the instrument board the angle between the direction of the transmitter and the horizontal.

The accuracy of the instrument is indicated by the fact that at a distance of half a mile from a transmitter of six watts output on 375 kilocycles, this angle was measured to an accuracy of one sixth of a degree.

The low-power low-frequency transmitter produces an "induction field" in the immediate vicinity of the antenna. This is a static field that surrounds the antenna equally in all directions (*i. e.*, not a beam) and stays with it, very little energy being radiated away in the form of waves. Since the intensity decreases rapidly with the distance, it extends, to a measurable degree, only a few miles. It is not subject to the freakish reflections and disturbances of high-frequency radiation.

The pick-up on the plane is actuated only by the in-

ductive effect of this field, not by radio waves. It does not interfere with the use of a high-frequency beam or other means for guiding the aviator to the vicinity of the field, but helps him to land from a high altitude as on a field in a valley between high mountain ranges.

TYPHUS

A MAJOR epidemic of typhus fever is unlikely in either England or, for the present at least, in Germany proper, even though the disease is widely prevalent, according to reports, in German-occupied countries and in Spain and perhaps in northern Africa.

Lice spread the disease, but it is not solely attention to cleanliness, and therefore fewer lice, that will help protect England and Germany from typhus fever epidemics. Two other factors are essential for the development of a major typhus fever epidemic: (1) A focus of typhus fever cases from which the lice can spread the disease; (2) a disorganized population.

Dr. R. E. Dyer, the newly-appointed director of the National Institute of Health of the U. S. Public Health Service, pointed out that "No big epidemic of typhus fever has ever taken place unless, in addition to lice and a typhus focus, there was also a badly disorganized population."

Dr. Dyer is an authority on typhus fever, having established the fact that endemic typhus fever in the United States is spread by the rat flea, instead of the body louse which spreads European typhus. War, famine and civil revolutions are the conditions necessary for the kind of disorganization of populations that is the third factor required to fan typhus fever into a large epidemic. Famine certainly is not present in England nor, according to reports, in the Reich proper. War has failed to disorganize the population in England and there are no reliable reports of any such disorganization in Germany.

Steps must, of course, be taken and apparently are being taken to prevent the spread of typhus to the populations in England and Germany from soldiers returning from typhus fever areas and from war prisoners and refugees. Delousing is one effective measure of preventing its spread. It was extensively practiced among the armies on the Western Front in World War I. Troops in the trenches could be frequently relieved and sent to the rear for short periods for delousing. Such a procedure is not practical under conditions of open warfare.

Those who survive an attack of typhus fever are immune to the disease. This is believed to give the Russians some advantage at present, since large numbers of men in the Russian army now may have acquired immunity of typhus during the epidemic in Russia between 1917 and 1921. The Germans are not immune.

Vaccines against typhus fever have been developed, but so far none has proved satisfactory. One developed by Dr. Herald N. Cox. of the U. S. Public Health Service, is being tested in Bolivia.—JANE STAFFORD.

THE WESTINGHOUSE SUPER-POWER TESTING LABORATORY

ELECTRICAL knockout blows of 2,000,000 kilowatts, equal to twice the power generated at any instant at Niagara Falls, were rendered harmless by improved protective devices, at the first public demonstration of Westinghouse's new super-power testing laboratory.

In demonstrations before Army and Navy officers, these knockout blows duplicated the effects of a short circuit, such as could be caused by a bar of steel thrown across the electric circuits in a power station by a saboteur, the severance of a power line so that it would fall to the ground, explosives planted on the ground, or an aerial bomb.

The torrent of power suddenly released produced flaming arcs 20 feet in length, exploded old-time safety fuses with detonations as loud as shellfire, and shattered six-inch timbers into kindling wood. But a new 12-foot-tall improved oil circuit-breaker snuffed out the arc in a twentieth of a second and by-passed the current into a chamber where it was choked off with magnetic plates. Applied to a power line, the circuit-breaker cuts out a short-circuited section, allowing the remainder of the system to function normally.

In another demonstration, a compressed-air circuit-breaker blew out a 1,500,000-kilowatt arc in a hundredth of a second. In a room-sized refrigerator, where temperatures 20 degrees below zero can be maintained, an outdoor power switch, encrusted with frost and dangling with icicles, was tested. At 120,000 volts the current flashed over the four-foot-high porcelain insulators with a blinding light and a thundering crash. Experiments like this indicate how much insulation a winter-proof switch must have.

The power for the 2,000,000 kilowatt flash was built up gradually by two 500-ton generators and then released suddenly in a maximum time of five seconds. This power, which is equivalent to 2,680,000 horsepower, if it could be delivered continuously, would light enough fluorescent lamps to girdle the earth twice at the equator. The sudden release of this energy caused the generators to recoil like guns. Special spring mountings took up the shock to prevent injury to the foundations.

THE SULFA DRUG AND PERITONITIS

A NEW method of using a sulfa drug to save patients suffering from dangerous peritonitis is reported by Dr. Julius Gottesman and Dr. Harold Goldberg, of Sydenham Hospital, New York City, in the *Journal* of the American Medical Association.

The method consists of injecting the drug into the abdomen. Sulfa drugs have been put directly into the abdomen when it is opened at surgical operation or in war wounds, but this is believed to be the first time a sulfa drug has been injected into the abdomen when there was no wound.

The patient given this new type of treatment was a two and one half-year-old Negro child suffering from acute appendicitis with generalized peritonitis. Because of the child's condition, the doctors did not believe removal of the appendix was advisable. On the tenth day of the child's illness, the abdomen was punctured with a long needle something like a hypodermic needle and about half a pint of pus was withdrawn. Sulfathiazole was then injected through this aspirating needle. A

second injection was made two days later, and the child was also given injections of sulfathiazole into the veins as well as other treatment.

Two days after the second injection of sufathiazole into the abdomen the child's temperature fell to normal and its general condition showed definite improvement. Within three weeks it had recovered from the serious infection and was able to go home. Two months later another attack of acute appendicitis occurred and at that time the appendix was removed.

The method of injecting the sulfa drug directly into the abdomen could be of value not only in peritonitis from appendicitis, but also in peritonitis due to pneumonia germs, gonorrhea or streptococci.

DETECTOR OF METAL FRAGMENTS IN WOUNDS

PIECES of metal may now be removed from war casualties and victims of accidents with unprecedented facility and speed. The old method using probes and x-rays often takes one or more hours compared to the new record of a few minutes.

The revolutionary technique is based on the use of an instrument known as the Moorhead Foreign-Body Finder. By means of this guide surgeons may definitely locate bits of steel or other metals easily and quickly. The instrument was designed by Colonel John J. Moorhead, of the U. S. Army, professor of traumatic surgery at the Army Post Graduate School in New York City. It was used for the first time in Tripler Hospital, Schofield Barracks, after the Japanese raid at Pearl Harbor on December 7.

On the morning of the attack Colonel Moorhead—a visitor in Honolulu—was lecturing to a group of physicians. When the call came for medical help he accompanied the doctors to the army hospital. His instrument was used successfully that day to locate fragments in twenty cases and in many more to prove the absence of any imbedded metal. It consists of a radio frequency circuit mounted in a box, with a movable coil or capacity attached by a wire and inclosed in a steel finger, about half an inch in diameter and about twelve inches long, which is water-tight; the wire to which it is connected is covered with rubber so that it may be detached and sterilized by boiling. As the indicator approaches a piece of metal there is a deflection on a milliammeter. One knob of the instrument adjusts for iron fragments and another for other metals.

In use the indicator is passed above or around the wound in two planes at right angles to each other. At the points of greatest deflection marks are made on the flesh. The projection of these points indicates the position of the metal fragment. If this is not sufficient the indicator may be introduced directly into the wound, even in lung, brain or abdomen.

Colonel Moorhead's instrument has many advantages over the old method using x-rays. It cuts the time needed to remove the fragments to a mere fraction of that formerly required. The instrument is cheap to construct and operate and constitutes an enormous saving over that of the ordinary x-ray outfit. The machine is easily portable. The box is about one by one by two feet and weighs approximately ten pounds.

ITEMS

THAT tanks for the storage of gasoline and other volatile liquids, refineries and other vital structures can be made almost invisible to approaching enemy bombers by a new type of low visibility paint, has been announced by Paul L. Hexter, vice-president of the Arco Company, Cleveland. The new paint, although dark in color, has heat deflecting qualities approaching those of aluminum paint, hitherto widely used for keeping oil storage tanks cool, but now unsuitable because it makes these tanks shining targets that can be seen for many miles. To blend with the surroundings or for camouflage, the tanks can be painted green, tan, black or four intermediate shades. Already in use by the government, the paint meets Navy specifications for infra-red reflecting powers.

EVERY American community needs "a soundly conceived, adequately financed and ably executed dental health program," according to Dr. Lon W. Morrey, director of public education of the American Dental Association. Dr. Morrey spoke at the Second Pennsylvania Health Institute in session at Harrisburg. He pointed out that demands for dental health education have been growing for the past twenty years and that to-day the movement has expanded to forty-two state health departments which now have dental units.

A NEW plan which solves the problems of middle-aged and older patients and dentists alike was described by its originator, Dr. Elmer S. Best, of Minneapolis, at a meeting of the Second District Dental Society of New York State. Under the plan, the difficult dental diseases of middle-aged and older patients are treated on a yearly fee basis by middle-aged and older dentists who are the more experienced. Dental specialties, concerned with diseases of patients in this age group, are lumped under a new name, gerodontia. Dr. Best explained that the increasing number of persons sixty-five and older among the general population are particularly difficult dental patients. Their teeth are more brittle and false teeth need constant supervision.

THAT phosphorus for war uses will pour from two TVA plants, one already in operation at Muscle Shoals, the other to be set up immediately on the Gulf Coast near Mobile, Ala., if Congress acts promptly on a recent Presidential recommendation, was stated by David E. Lilienthal, TVA chairman, in a recent address. Combined capacity of the two plants will be 33,000 tons of elemental phosphorus a year. The Muscles Shoals plant has been in operation for several years, producing high-concentration phosphate fertilizers for use in the national soil restoration program. Relatively simple conversion now in progress will enable it to produce the pure element, whose war uses include incendiary bombs and concealing smokes. Burns from fragments of phosphorus bombs are disabling and slow to heal, but the white smoke produced by the burning element is harmless when breathed.